Ground-Water Conditions in the Rincon and Mesilla Valleys and Adjacent Areas in New Mexico

By C. S. CONOVER

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By C. S. Conover

ABSTRACT

The Rio Grande in New Mexico winds through a succession of basins lying between isolated northward-trending mountain ranges constituting part of the Basin and Range physiographic province. The flood plain of the Rio Grande, in general, consists of wide and narrow sections corresponding to alternately soft and hard rocks traversed by the river. The Rincon and Mesilla Valleys are the two southernmost expanded flood plains of the Rio Grande in New Mexico and are parts of the Rio Grande project of the U. S. Bureau of Reclamation. Water for the project is stored at Elephant Butte Reservoir, which was constructed to equalize the flow of the river to the Rio Grande project because large variations occur in the natural flow. Caballo Dam, about 20 miles south of Elephant Butte Dam, permits control of irrigation water to the project after its use for generating electric power at Elephant Butte Dam.

After the heavy precipitation of 1941, Elephant Butte Reservoir filled to capacity, 2,197,600 acre-feet, but drought conditions followed, and by early 1946 the reservoir contained less than a year's normal supply of water for the project. The Elephant Butte Irrigation District, the administrative control agency for the New Mexico part of the project desired to know whether it would be advisable to try to develop a supplemental ground-water supply for the district. The District and the U. S. Geological Survey signed a cooperative agreement whereby the Ground Water Branch of the Survey would make a ground-water study of the area to determine the feasibility of using ground water to supplement the present supply of surface water for irrigation in the district.

Below Elephant Butte Dam the Rio Grande flows westward for about 6 miles across the northern end of the Caballo Mountains, a fault-block mountain of pre-Cambrian, Paleozoic, and Cretaceous rocks dipping to the east. The river then turns south, following the western base of the mountains. The land rises gently west of the river in a series of pediment slopes toward the Black Range, which forms the Continental Divide. At the south end of the Caballo Mountains the river swings southeastward and crosses the northward-trending Jornada del Muerto, an intermountain basin, and its southern extension, La Mesa, the river being bounded on the east by the Dona Ana, Organ, and Franklin Mountains. These mountains consist largely of tilted Paleozoic sedimentary rocks on a basement of pre-Cambrian rocks, but they also contain Tertiary volcanic rocks. The bolsonlike troughs between the mountains east and west of the river are filled with Tertiary and Quaternary sands, silts, clays, and gravels, constituting a valley fill that belongs largely to the Santa Fe formation of Miocene and Pliocene age. Overlying this material and terrace gravels, basalt lava flows, and the flood-plain deposits of the Rio Grande, the latter forming the smooth valley floor, generally bordered by steep bluffs, which may exceed 100 feet in height

Ground water occurs beneath the plains of La Mesa and Jornada del Muerto. Generally the water is unconfined—that is, water-table conditions exist. The map showing contours of the water table indicates that the ground water flows from La Mesa toward the valley rather than following a possible former course of the Rio Grande toward Mexico. The hydraulic gradient of the water table ranges from as little as 1.2 feet to the mile in the central part of La Mesa, where the aquifer is thick, to more than 100 feet to the mile on the steep slopes along the mountains, where the aquifer is relatively thin and the water is apparently upheld by the buried impermeable rocks of the mountains. The depth to water is generally greatest (more than 400 feet) in the central parts of the

plains, and least (less than 100 feet) toward the edges of the plains, near the mountains, and along the valleys. The ground water beneath the plains is recharged from precipitation upon the upland and mountainous areas. In the La Mesa area, the recharge is estimated to be about 0.02 inch of water per year. The average annual precipitation is a little less than 10 inches. The ground water from beneath the plains is discharged to the Rio Grande at a rate estimated to be less than 1 cubic foot a second per mile of valley, with that part in the Mesilla Valley approximating 40,000 acre-feet a year.

Water of the Rio Grande which generates hydroelectric power at Elephant Butte Dam is stored in Caballo Reservoir for irrigation use. Diversions from the Rio Grande to the irrigated lands of the district are made at Percha Dam in the Rincon Valley and at Leasburg and Mesilla Dams in the Mesilla Valley. A drainage system, consisting of 42 miles of open drains in the Rincon Valley and 226 miles in the Mesilla Valley, discharges return irrigation seepage to the Rio Grande.

The depth to the water table in the valley fill along the flood plain in the Rincon and Mesilla Valleys is generally less than 10 feet. The ground-water level rises during the irrigation season to a high level in late August and declines during the nonirrigation season to its lowest level in February or March. The water table, in general, slopes down the valley at a rate of about 4.5 feet to the mile, which is essentially the same as that of the valley floor. The ground water in the valley fill of the flood plain is recharged by infiltration of water applied to the land for irrigation, seepage from canals, seepage from certain stretches of the river, precipitation upon the flood plain, and ground-water flow from the mesas and other elevated areas. Recharge by direct infiltration of precipitation is, on the average, small.

Discharge of ground water in the valleys is essentially by seepage to the drains and parts of the river and by transpiration by plants in areas of high water table. Discharge of ground water in the project, as represented by the water returned to the river by the drains, is 249,400 acre-feet a year when a normal supply of surface water is available for irrigation. A quantity of ground water, which has not been exactly determined, is discharged directly to the river in certain stretches.

The coefficient of transmissibility of the alluvial deposits in the Rincon and Mesilla Valleys averages 75,000 gallons a day per foot, as determined from pumping tests on 7 wells and from the relation between the accretion to 7 drains and the slope of the water table perpendicular to them.

Ground water obtained by pumping in the Rincon and Mesilla Valleys does not represent an additional supply or new source of water to the project, but rather a change in method, time, and place of diversion of the supplies already available.

Sufficient water for irrigation can be obtained from wells throughout the major part of the Rincon and Mesilla Valleys. Wells will "sand up" and special well construction may be necessary to control it. Water for irrigation, generally in small amounts, can be obtained by drilling wells on the low bench lands that border the valley floor and in the arroyos cut in them. Some wells in these areas will have only small yields.

In 1946 the anticipated shortage of surface water gave impetus to the drilling of wells for irrigation water in the Mesilla and Rincon Valleys. The number of irrigation wells increased from 11 at the end of 1946 to about 56 at the end of 1947. By February 1948, 14 additional wells had been constructed or were under construction.

Some of the lands now irrigated from wells do not have water rights under the Rio Grande project. There are about 15,000 acres of such lands on the flood plain and bordering higher land which could be irrigated by ground water. These lands, if developed, would ultimately utilize about 38,000 acre-feet of water annually on a basis of 2.5 acre-feet per acre.

The writer concludes that in a hypothetical year having only 50 percent of a normal supply of surface water available for diversions, the project lands would require an additional acre-foot per acre of water from wells to assure successful irrigation of the crops. However, because of the reduction in flow of the drains caused by pumping and because of losses in distribution, the use of water from wells to supply this deficit would require pumping 2.42 acre-feet per acre, or 213,000 acre-feet a year for the 88,000 acres of water-right land in New Mexico. Of the amount pumped, it is calculated that all but 63,000 acre-feet would be diverted from surface-water flow. If supplemental pumping were resorted to for 5 successive dry years, continued pumping would be necessary for 3 to 4 years after a return to normal surface supply so as to permit bypassing of the required share of water to the El Paso district, awaiting the restoration of ground-water storage by recharge from surface water.

The total cost of pumping equipment and pumping of this supplemental water for a period of 5 years with about 50 percent of normal surface supply, such as has been recorded in the past at San Marcial gage above Elephant Butte Reservoir, would be approximately one-fifth of the resulting additional gross crop returns, on the basis of the average gross return per acre from 1937 to 1946.

Substitution of pumping of ground water for the usual winter releases of surface water for irrigation of a small percentage of the lands would result in a saving to the project of possibly 34,000 acre-feet of water annually if no water were allowed to bypass the project in the winter.

The chemical quality of the shallow ground water in the alluvium of the Rincon and Mesilla Valleys is slightly poorer than that of drain water but is satisfactory for most irrigation requirements. Comparatively good water is obtained on the surrounding high lands and in the arroyo beds.

As water pumped from wells in the Rincon and Mesilla Valleys is not an additional or new supply but rather water that is normally intercepted by the project, continuing records should be kept of the amount of water pumped, of water-level measurements, and of the location and performance of the irrigation wells. Measurements of the flow of the drains should be made periodically and at enough points to determine the magnitude of the effect of pumping upon the flow of the drains.

INTRODUCTION

PURPOSE AND SCOPE OF INVESTIGATION

Prolonged drought conditions on the Rio Grande watershed during the preceding 5 years reduced surface-water storage so greatly that a serious water shortage seemed to impend in 1947, and became more serious in 1948, for the Rio Grande project of the Bureau of Reclamation. The annual supply of water allowable to the project under the terms of the Rio Grande Compact is 790,000 acre-feet, including 60,000 acre-feet required for delivery to Mexico. The total amount of water available to the project, including about 105,000 acre-feet of water stored in El Vado Reservoir and owed to the project, had dropped to about 465,000 acre-feet by the second week of August 1947. The amount of stored water in Elephant Butte Reservoir August 12, 1947, was 317,000 acre-feet, the lowest on record since operation of the reservoir began in 1916, and 29 percent of the average from 1915 to 1947 for the last day in August. On the same date, the available 43,000 acre-feet of stored water in Caballo Reservoir was about average. With another month of irrigation due in 1947, the carry-over water storage would be very small and unless very substantial replenishment occurred there would be insufficient water for irrigation in 1948. Rationing of water for the 1948 year was announced in August 1947. The initial allotment of water was set at 1 acre-foot per acre, subject to change if more water became available. In addition, no winter releases of water were to be made, and no water was to be delivered to lands lacking a full water right.

In 1946 the Elephant Butte Irrigation District, which comprises the valley lands of the Rincon and Mesilla Valleys of the Rio Grande in the New Mexico part of the Rio Grande project, anticipated a shortage of surface water because of the low stage of Elephant Butte Reservoir. One of the measures considered to relieve the impending shortage was the use of ground water for irrigation. Intelligent planning of the use of ground water required a knowledge of the ground-water conditions of the area. Accordingly, the district requested the U. S. Geological Survey to make a study of the possibilities of pumping ground water for irrigation, mainly from the standpoint of productiveness of wells and of the effect that the pumping of wells would have upon the surface-water supply in the river and drains.

Field work, begun in 1946 by the author, consisted of obtaining available information concerning the wells in the valley, primarily wells that would produce sufficient water for irrigation and municipal supply. Pumping tests were made on a few wells to determine the hydrologic constants of the aquifer and the specific capacities of the wells. Considerable data on file at the U. S. Bureau of Reclamation, relative to the ground-water conditions in the valleys in the early years, were studied. These data consisted of measurements of depth to water in a number of auger holes over a period of years; depth-to-water maps of the Mesilla Valley prior to, and subsequent to, installation of the drains; profiles of the water table across various drains and across the entire valley; land classifications; records of surface-water diversions and applications and return flow of the drains in past years; annual project histories; and other related information.

In 1947, G. R. Chenot of the Geological Survey gathered data concerning wells on the upland mesa lands bordering the Mesilla Valley. He attempted to visit all known wells to determine their altitudes, measure the depth to water in them, and obtain other available data. Information concerning newly developed irrigation wells in the valleys was obtained at intervals, and periodic measurements of water levels were made in a few observation wells in the valleys. Water samples for chemical analysis were collected from a number of wells in the valley and on the mesa lands.

In February 1947, 2 lines of auger holes were placed across the Park Drain on the Seale and Holt roads south of Mesilla Park in order to determine the relation between the slope of the water table and the accretion of ground water to the drain. Water levels were measured in these wells every 2 weeks by the Geological Survey, and the drain flow was measured every month by the Bureau of Reclamation. In the same month, an auger hole was installed at the shelter for weather instruments at the New Mexico College of Agriculture and Mechanic Arts to obtain a daily record of the water level. Observations on this well have been made by those employed to record the weather observations.

The studies in Rincon and Mesilla Valleys were made under the direction of A. N. Sayre, geologist in charge, Ground Water Branch, Water Resources Division of the U. S. Geological Survey, and under the immediate supervision of C. V. Theis, district geologist in charge of ground-water investigations in New Mexico.

PREVIOUS INVESTIGATIONS

The earliest published report available on the ground-water conditions in the Mesilla Valley is that by Slichter (1905). At the time of his investigation considerable interest was exhibited in the pumping of ground water from the valley fill as a means of supplementing the erratic flows of the Rio Grande. Slichter (1905, p. 13) investigated the underflow of the Rio Grande at the narrows above El Paso and determined that the underflow did not exceed 50 gallons a minute. A number of auger test holes were bored in a line across the valley on the east side of the river in the vicinity of Mesilla Park to determine the gradient of the water table and the changes caused by flows in the Rio Grande. Slichter (1905, p. 27-29) determined that the greater part of the underflow was evidently derived from the river and that only a small amount—possibly about 0.5 cubic foot a second per mile along the valley—was derived from the adjoining mesas. Data are given for pumping tests made upon 12 irrigation wells near Las Cruces and Berino. Specific capacities of the wells ranged from a minimum of 5.8 to a maximum of 88.0 gallons a minute per foot of drawdown (Slichter, 1905, p. 34).

Lee (1907) in his report on the water resources of the Rio Grande valley gave data on a number of wells in the Mesilla Valley, including 6 that had not been previously reported by Slichter. He discussed the quantity, source, and probable disposal of the ground water in the Mesilla Valley and concluded that the ground water was probably discharged by evaporation in the valley (Lee, 1907, p. 50). Although a few data indicated the possibility of ground-water flow into Mexico, Lee believed, because of the downcutting of the Rio Grande in the Mesilla Valley and the accumulation of surface water in the gravels of La Mesa, that the flow from La Mesa, should be toward the Rio Grande rather than away from it (Lee, 1907, p. 40, 50).

The rising water table in the Mesilla Valley caused by the increased dependable water supply after the beginning of operation of Elephant Butte Dam in 1916 made installation of drains necessary. Preparatory to the installation of drains, auger holes were installed throughout the valley by the Bureau of Reclamation and water-table maps were prepared from the measurements of the water level. The results of the ground-water observations were incorporated in the annual project histories of the Rio Grande project and in a drainage report by L. R. Fiock of the Bureau of Reclamation in February 1917.

Dunham (1935) discussed the geology of the Organ Mountains and noted briefly the water conditions in a few of the mines.

The report of the Rio Grande joint investigation, 1936 to 1937, contains only casual mention of the ground-water conditions in the Mesilla Valley, except with respect to the quality of the drain and subsoil waters (National Resources Committee, 1938, p. 451). In the report Kirk Bryan states that, because the lands west of the Rincon Valley are higher than the valley, the Rincon Valley must receive water from, rather than lose water to, the west. He also states that because the ground-water levels in La Mesa appear to be higher than the floor of the Mesilla Valley, the Mesilla Valley must receive ground water from La Mesa, and inasmuch as the enclosed basins south of La Mesa appear to have altitudes higher than the valley floor above El Paso, flow of ground water south to Mexico from La Mesa appears unlikely (National Resources Committee, 1938, p. 225).

Chemical analyses of the surface, drain, and subsoil waters of the Rincon and Mesilla Valleys, sampled during the Rio Grande joint investigation, are contained in a report by Scofield (1938).

A reconnaissance investigation of the water supply for Las Cruces was made in September 1936 by C. V. Theis[1] of the Geological Survey. He concurred with the city officials of Las Cruces in locating the wells of the city on the mesa land to the east and believed it possible to obtain water of a better quality than that found in the valley.

A reconnaissance report was prepared by the Bureau of Agricultural Economics[2] on the possibility of obtaining water supplies for a settlement in the southern part of the Jornada del Muerto, east of the Dona Ana Mountains. The report included data on a few stock wells and stated that the depth to water was in excess of an economic pumping lift for irrigation.[3]

ACKNOWLEDGMENTS

The writer acknowledges the cordial assistance of members of the Bureau of Reclamation who made available data concerning all aspects of the Rio Grande project, frequently spending a considerable amount of their time, especially L. R. Fiock, project manager, and W. F. Resch, acting superintendent of the Rio Grande project in El Paso. Mr. Resch also made many helpful comments. The writer's thanks are also due E. S. Mayfield, division engineer, Las Cruces division; Joe Carbine and Mr. Williams, watermasters for the Mesilla Valley, for general information, for monthly meas-

[1]Theis, C. V., 1936, Memorandum on water supplies at Las Cruces: U. S. Geol. Survey unpublished report, Albuquerque, N. Mex., 9 p.
[2]Bureau of Agriculture Economics, 1939, Reconnaissance report on possibilities for water facilities for the southern Jornada del Muerto, Dona Ana County, N. Mex., U. S. Dept. Agr., (unpublished), 14 p.
[3]Idem, p. 11, 12.

urements of the flow of the Del Rio Drain, and aid in finding irrigation wells; to M. B. Bonor, watermaster for the Rincon Valley, who helped in finding irrigation wells; and Mr. Sadler of the Las Cruces office for his help in obtaining data on file. Nearly all the data in this report concerning irrigated acreages, diversions, drain flow, and water levels in past years were obtained from the Bureau of Reclamation.

Albert Curry, assistant director of the Agricultural Experiment Station at State College, gave permission and made arrangements for the pumping test on the college well and furnished valuable data pertinent to the irrigation wells of the college. Professor Overpeck also assisted in the pumping test and arranged for the daily observations in the auger hole at the weather-instruments shelter.

Grateful acknowledgment is especially due John L. Gregg, treasurer-manager of the Elephant Butte Irrigation District, who, from his detailed knowledge of the area, made many very helpful comments and suggestions throughout the study.

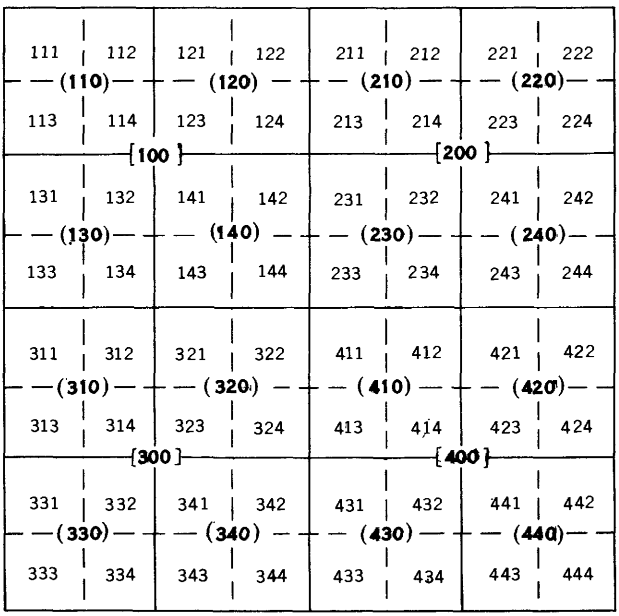
The well drillers were invariably helpful in supplying what information they had concerning wells, and the well owners and residents of the area were courteous and helpful; their assistance is appreciated.

WELL-NUMBERING SYSTEM

The system of numbering wells shown in this report is the same as that used in other parts of New Mexico. The system is based on the common designations of public land divisions, and by means of it the well number, in addition to designating the well, locates its position to the nearest 10-acre tract. The number is divided into four segments by periods. The first segment denotes the township north or south of the New Mexico base line, the second denotes the range east or west of the New Mexico principal meridian, and the third denotes the section. In a county such as Dona Ana County, where wells are situated both east and west of the principal meridian, and E is added to the second segment of the well number if the well is east of the principal meridian, but no letter is added if the well is west of the principal meridian. In counties in which no confusion can arise, the direction east or west of the meridian is not given.

The fourth segment of the number, which consists of 3 digits, denotes the particular 10-acre tract in which the well is situated. For this purpose, the section is divided into four quarters, numbered 1, 2, 3, and 4, in the normal reading order, for the northwest, northeast, southwest, and southeast quarters, respectively. The first digit of the fourth segment gives the quarter section, which is a tract of 160 acres. Similarly, the quarter section is divided into four 40-acre tracts numbered in the same manner, and the second digit denotes the 40-acre tract. Finally, the 40-acre tract is divided into four 10-acre tracts, and the third digit denotes the 10-acre tract. Thus, well 23.2E.29.342 in Dona Ana County is in the NE1/4SE1/4SW1/4 sec. 29, T. 23 S., R. 2 E. If a well cannot be located accurately to a 10-acre tract, a zero is used as the third digit, and if it cannot be located accurately within a 40-acre tract, zeros are used for both the second and third digits. If the well cannot be located more closely than the section, the fourth segment of the well number is omitted. When it becomes possible to locate more accurately a well in whose number zeros have been used, the proper digit or digits are substituted for the zeros. Letters a, b, c, and d are added to the last segment to designate the second, third, fourth and suceeding wells listed in the same 10-acre tract.

The following diagram shows the method of numbering the tracts within a section:



In the well tables, pages 163 to 195 of this report, the wells are arranged in numerical sequence of the well location number, wells east of the principal meridian in a township preceding those west of the meridian.

FEATURES OF THE AREA

LOCATION AND GENERAL FEATURES

The area covered by this report includes the valley lands of the Rincon and Mesilla Valleys in New Mexico and the adjacent mesa lands bordering, primarily, the Mesilla Valley.

The Rincon and Mesilla Valleys, in the south-central part of New Mexico, are two of the many widened parts of the Rio Grande valley that are separated by narrows and çanyons in the eroded channel. The Rincon Valley lies north of the Mesilla Valley, in Sierra and Dona Ana Counties, N. Mex.; the Mesilla Valley is in Dona Ana County, N. Mex. and El Paso County, Tex. (See fig. 1 and pls. 1-3.)

The largest community in the Rincon and Mesilla Valleys is Las Cruces, N. Mex., 45 miles north of El Paso, Tex. It had an estimated population of 12,000 in 1946, an increase of 43 percent from 8,385 in 1940. The only other town of appreciable size is Hatch, about 36 miles north of Las Cruces, in the Rincon Valley. It had an estimated population of 1,400 in 1946, an increase of 70 percent from 822 in 1940. El Paso, in the El Paso Valley of the Rio Grande, is a nearby trade territory and tourist center with a population of about 109,000. Across the Rio Grande from El Paso is Ciudad Juarez, Mexico. Hot Springs (named Truth or Consequences in 1950), about 40 miles north of Hatch, had an estimated population of about 5,000 in 1946. It is a trade territory and health and recreation resort. Various small settlements are distributed along the Rincon and Mesilla Valleys, a few of which are Arrey, Derry, Garfield, Salem, and Rincon in the Rincon Valley, and Dona Ana, Mesilla, Mesilla Park, State College, San Miguel, La Mesa, Berino, La Union, Anthony, and Canutillo in the Mesilla Valley.

The New Mexico College of Agriculture and Mechanic Arts is at State College, about 2 miles southeast of Las Cruces. White Sands Military Proving Ground is on the east side of the Organ Mountains, about 20 miles east of Las Cruces.

The area is served by the Atchison, Topeka, and Santa Fe Railway which runs along the Jornada del Muerto, east of the Caballo Mountains that flank the Rincon Valley on the east, and enters the Rincon Valley at Rincon about 5 miles east of Hatch. From Rincon the main line extends southward in the Rincon and Mesilla Valleys through Las Cruces to El Paso, and a branch line goes westward through Hatch to Deming. U. S. Highway 85 traverses the Rincon and Mesilla Valleys from the north through Hatch to Las Cruces

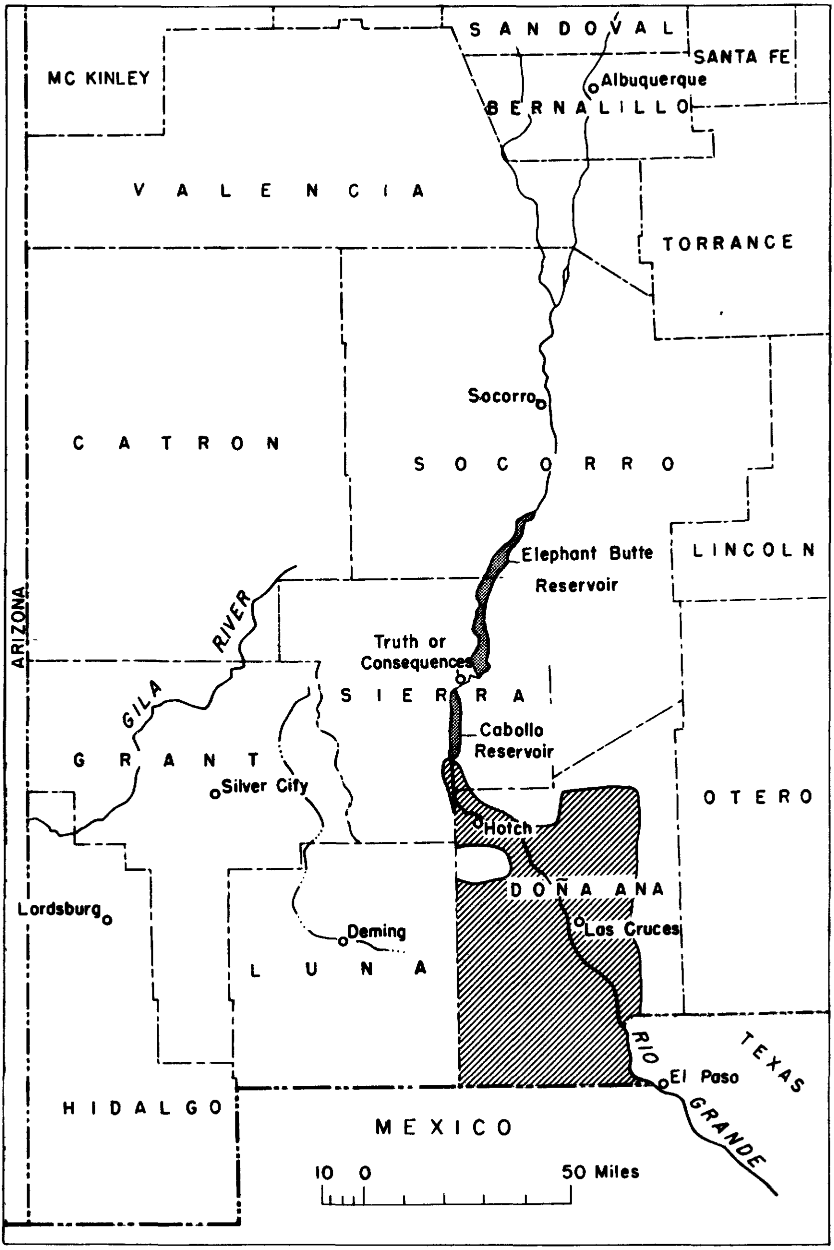


Figure 1. —Map of southwestern part of New Mexico showing the area covered by the report.

and El Paso, and U. S. Highway 70 crosses the Mesilla Valley at Las Cruces. State Route 26 from Deming enters the Rincon Valley at Hatch.

The main industry of the valleys is farming, with 68 percent of the crop acreage in 1946 in cotton, 19 percent in alfalfa, and 4 percent in pecans. The pecan acreage is increasing. Some truck crops are grown quite successfully. Cantaloupes, chili, and onions each made up about 1 percent of the crop acreage in 1946. The total value of crop production for the Rio Grande project in 1946, in New Mexico and Texas, was $39,463,471 or $251.90 per acre, and in the New Mexico section alone was $20,912,574. Many cotton gins, 2 cottonseed-oil mills, and 2 canneries are located in the area, and plans for erection of an alfalfa mill are under way.

CLIMATE

The climate of Dona Ana County, N. Mex., typical of the climate of the arid to semiarid parts of southwestern United States, is characterized by clear and sunny days, large diurnal temperature ranges, low humidity, and scant rainfall.

Weather records maintained by the U. S. Weather Bureau at State College, south of Las Cruces, show a mean annual temperature of nearly 60 F. for the 89 years of record. The average maximum temperature for July is about 93 F. and the average minimum, about 65 F. In January the average maximum temperature is 58 F. and the average minimum is 26 F. Large diurnal temperature changes are common, summer temperatures sometimes exceeding 100 F. during the day and falling below 60 F. at night. There is a long frost-free growing season of about 200 days a year.

The low average relative humidity of less than 50 percent is a factor in the high diurnal temperature changes and is also partly responsible for the high annual evaporation of nearly 100 inches.

The rainfall in the valleys is scant, greater amounts falling on the surrounding high lands that intercept the storms. The average annual rainfall at State College is 8.68 inches and that at the Jornada Experimental Range on the mesa, northeast of Las Cruces, is 9.60 inches. The higher peaks of the Organ and Franklin Mountains probably receive in excess of 15 inches a year. The distribution of precipitation during the year is such that more than half the yearly total normally falls in July, August, and September.

This distribution of rainfall is advantageous for growing crops, but it is totally inadequate in amount and must be supplemented by irrigation.

Variation in the time and amount of precipitation causes a variation in the time and amount of irrigation water applied to crops and also a variation in the ground-water levels. Relation of the precipitation in 1947 and part of 1948 to the water level, measured daily in three auger test holes, is shown in figure 6.

The following tables taken from reports of the U. S. Weather Bureau show data on precipitation at the Agricultural College, Hatch, and Caballo Dam from 1930 to 1948. The precipitation in 1941 of 19.60 inches at the Agricultural College was the greatest for the 89 years of record, exceeding the previous record in 1881 by 4.55 inches. The least annual rainfall was 3.61 inches, in 1860.

Annual precipitation at stations in Rincon and Mesilla Valleys, N. Mex., 1930–47

Year	Agricultural College (Altitude, 3,863 feet)		Hatch (Altitude, 4,042 feet)	Caballo Dam
	Precipitation (inches)	Departure from average	Precipitation (inches)	Precipitation (inches)
1930	6.88	-1.80	....	....
1931	13.26	+4.58	16.13	....
1932	8.83	+.15	7.43	....
1933	4.71	-3.97	8.57	....
1934	4.62	-4.06	4.03	....
1935	12.67	+3.99	8.20	....
1936	9.50	+.82	7.65	....
1937	7.01	-1.67	7.09	....
1938	9.27	+.59	13.56	....
1939	5.77	-2.91	10.15	8.41
1940	9.22	+.54	6.47	6.97
1941	19.60	+10.92	18.22	18.82
1942	9.80	+1.12	8.46	8.30
1943	7.55	-1.13	7.63	8.12
1944	9.77	+1.09	8.78	9.92
1945	5.77	-2.91	4.58	6.19
1946	7.14	-1.54	8.56	5.57
1947	6.08	-2.60	....	4.88

Average monthly precipitation at Agricultural College, N. Mex.

	Inches
January	0.32
February	.43
March	.32
April	.22
May	.30
June	.55
July	1.73
August	1.73
September	1.35
October	.70
November	.54
December	.49
Annual	8.68

Daily precipitation, in inches, at Agricultural College, N. Mex., 1947–48

[No precipitation on days not shown]

Date	Amount	Date	Amount	Date	Amount
1947		*1947*—Con.		*1947*—Con.	
Jan. 2	0.09	June 19	0.03	Nov. 17	0.07
7	.07	July 13	.25	18	.06
8	.47	16	.03	Dec. 3	.18
9	.02	Aug. 3	.14	31	.32
17	.46	13	.10		
Feb. 27	.05	15	.07	*1948*	
Mar. 6	.36	16	.42	Jan. 28	.18
18	.12	18	1.06	Feb. 4	.06
Apr.	Trace	20	.06	5	.28
May 8	.08	21	.18	6	.01
9	.01	23	2.88	12	.03
10	.04	30	.07	25	.31
22	.01	Sept.	Trace	26	.74
23	.04	Oct.	Trace	27	Trace
26	.01	Nov. 13	.06	Mar. 18	.02
June 17	.08	14	.26	30	.03
18	.38	16	.15	31	.11

TOPOGRAPHIC FEATURES

Dona Ana County is traversed diagonally by the Rio Grande (see pl. 1), which flows in the Rincon and Mesilla Valleys, two of the many widened lowlands along the river. The valleys have relatively smooth alluvial floors ranging in width from a few hundred feet to a maximum of about 5 miles in the vicinity of Las Cruces. The altitude of the Rincon Valley ranges from about 4,140 feet above sea level at Caballo Dam to 3,974 feet at Leasburg Dam, a slope of about 4.5 feet to the mile. Hatch, near the center of the valley, has an altitude of 4,054 feet. The altitude of the Mesilla Valley ranges from 3,974 feet above sea level at Leasburg Dam to 3,720 feet at the El Paso station 4 miles northwest of El Paso, a slope also of about 4.5 feet to the mile. Las Cruces, near the upper part of the valley, has an altitude of 3,897 feet.

The valleys are bordered by steep bluffs, about 50 to 100 feet high, of loosely cemented sand, silt, clay, and gravel. From the bluffs, gently inclined plains extend back to the mountain. The plain or mesa on the east side of Mesilla Valley that extends north from Las Cruces to San Marcial, a distance of about 100 miles, is called the Jornada del Muerto. It is nearly flat detrital plain, 10 to 20 miles in width, between the San Andres Mountains on the east and the Caballo and Fra Cristobal Mountains on the west. It has no drainage lines except at the southern end, near the river, but numerous shallow depressions throughout its length catch storm waters and form temporary lakes. The Jornada del Muerto slopes southward about 4.5 feet to the mile (Lee, 1907, p.10) The altitude of the center of the plain, at the lowest point east of the Dona Ana Mountains, about 9 miles northeast of Las Cruces, is about 4,290 feet, or 360 feet above the level of the Rio Grande to the west.

The plain west of the Mesilla Valley that extends southward from near Las Cruces into Mexico is known as La Mesa. It is similar to Jornada del Muerto in many respects. Its altitude at the northern end is approximately the same as that of the southern end of Jornada del Muerto, and the two formed a single plain previous to the excavation of the Mesilla Valley. La Mesa has a width of 20 miles or more and is undissected by erosion and devoid of surface drainage. It contains several broad, shallow depressions (Lee, 1907, p. 10). The slope of La Mesa is southward about 70 feet in 30 miles, slightly more than 2 feet to the mile, or about half that of Jornada del Muerto. The altitude of La Mesa west of Black Mountain is about 4,200 feet, or 375 feet above the level of the river to the east.

The Caballo Mountains parallel the Rincon Valley a few miles to the east and separate it from the Jornada del Muerto. West of the Rincon Valley the plains extend nearly to the Mimbres Mountains, about 20 miles distant. At the southern end of the Rincon Valley is Selden Canyon, which has been eroded into the igneous rocks that form the Sierra de las Uvas.

The northward-trending Organ Mountains, are about 15 miles east of Las Cruces. The highest peak is Organ Needle, 9,012 feet above sea level. The Franklin Mountains extend south from the Organ Mountains to the Rio Grande at El Paso. The San Andres Mountains extend northward from the Organ Mountains about 70 miles and flank the Jornada del Muerto on the east. (See pl. 1.)

The West Potrillo and East Potrillo Mountains, which reach an altitude of 5,957 feet at Mount Riley, lie west of La Mesa and extend about 25 miles northward from the international boundary.

Other minor mountains are: the Picacho Mountain and Robledo Mountain, maximum altitude 5,876 feet, on the west side of the Rio Grande and extending northward from the vicinity of Las Cruces to Leasburg Dam; Dona Ana Mountains, maximum altitude 5,829 feet, on the east side of Mesilla Valley north of Las Cruces; Tortugas Mountain, elevation 4,912 feet, about 3 miles east of State College; and Black Mountain, about 6 miles west of Mesilla Valley in the vicinity of Chamberino. (See pl. 1.)

The Rio Grande flows southward from Truth or Consequences in Sierra County to the vicinity of the Sierra-Dona Ana County line, thence southeastward across Dona Ana County to El Paso, Tex. The flow of the Rio Grande in this area in summer is maintained principally by releases from Elephant Butte and Caballo Reservoirs and in the winter by return drainage flow. Prior to construction of Elephant Butte Dam the river was often dry for months at a time. Slichter (1905, p. 21) states that there was no water in the Rio Grande below El Paso for 9 months prior to August 25, 1904.

Many tributaries enter the Rincon and Mesilla Valleys. Most are short arroyos that have been formed by storm runoff and carry water only for short periods after sudden, heavy showers, which occur principally during the summer. A few of the tributaries, particularly those that rise in the mountains west of the Rincon Valley, have large drainage areas, and have small perennial flows in their upper reaches. The small perennial flows do not reach the Rio Grande, either being diverted for irrigation or sinking underground shortly after leaving the mountains. Only a few large arroyos enter the Mesilla Valley, the principal ones entering from the east in the vicinity of Las Cruces. (See pls. 1-3.)

There are a few springs in the area, particularly in the Organ Mountains. The best known is Radium Springs, a mineral hot spring at the head of the Mesilla Valley. A small spring, Derry warm springs, issues from the limestone bluff on the east side of the Rincon Valley about a mile north of the Sierra-Dona Ana County line. (See analyses, p. 152, 153.)

RIO GRANDE PROJECT

The Rio Grande project of the Bureau of Reclamation includes most of the valley lands of the Rio Grande in New Mexico and Texas from Caballo Dam southward to a point about 40 miles below El Paso, a distance of about 130 miles. From Caballo Dam to Selden Canyon, a distance of about 30 miles, the Rio Grande flows in the Rincon Valley, which has a maximum width of about 2 miles. (See pl. 2.) Below Selden Canyon the valley floor widens into the Mesilla Valley, which extends about 55 miles southeastward to "The Pass," 4 miles above El Paso. The Mesilla Valley is one of the larger widened areas along Rio Grande and has a width of about 5 miles near Las Cruces. (See pl. 3.) The El Paso Valley extends about 90 miles southward from El Paso and ranges in width from 4 to 6 miles, but only the upper 40 miles is included in the Rio Grande project.

The water for the Rio Grande project is stored in Elephant Butte Reservoir, which has a capacity of 2,197,600 acre-feet, and in Caballo Reservoir, which has a capacity of 345,870 acre-feet, about 28 miles below Elephant Butte Dam. Water released from Caballo Reservoir is diverted from the Rio Grande to the canals in the Rincon Valley by the Percha Dam, about 2 miles below Caballo Dam; in the Mesilla Valley by the Leasburg Dam at the head of the valley and by the Mesilla Dam, about 5½ miles southwest of Las Cruces; and in the El Paso Valley by the American Dam, about 3 miles northwest of El Paso. Water for the Mexican side of the El Paso Valley, generally referred to as the Valle de Juarez, is diverted at the International Dam, about 2 miles below the American Dam.

Gaging stations, equipped with automatic water-stage recorders, are maintained at various points on the Rio Grande by the U. S. Bureau of Reclamation and by the International Boundary and Water Commission. The stations on the Rio Grande pertinent to this report are as follows: "Below Caballo Dam," 0.8 mile below Caballo Dam and 1.5 miles above Percha Dam; "Leasburg Dam;" "El Paso station," above American Dam; and "below American Dam," 0.6 mile below American Dam and 1.5 miles above International Dam. The flow at the El Paso station since the beginning of operation of the American Dam, in June 1938, has been generally computed as the sum of the flow at "below American Dam" and the diversions from the American Dam to the American canal. Prior to installation of the gage "below Caballo Dam," in February 1938, records of flow were kept at Percha Dam. Small accretions to the river take place between the Caballo Dam gage and Percha Dam. Diversions into the Bonita Lateral from Caballo Dam, about 1,000 to 2,000 acre-feet per year, are not included in records at "below Caballo Dam" station.

An extensive system of open drains has been constructed, covering practically the whole area of the project. Water from 42 miles of drains in the Rincon Valley is discharged into the river above Leasburg Dam, and water from 226 miles of drains in the Mesilla Valley, except from two drains totaling 12 miles, is discharged into the river below Mesilla Dam to be diverted for reuse in the El Paso Valley portion of the project and in Mexico. (See pls. 2 and 3.)

The total area of land irrigated in the Rio Grande project in 1946 was 156,899 acres, of which 17,000 acres was in the Rincon Valley, 83,911 acres in the Mesilla Valley, and 55,988 acres in the El Paso Valley. Of the irrigated land in the Rincon Valley, 3,087 acres was in Sierra County, and of that in the Mesilla Valley, 10,812 acres was in Texas. The division of irrigated lands in the project amounted to 90,099 acres in New Mexico and 66,800 acres in Texas.

Land that is "subject to construction charges" of the project is referred to as "SCC" land and carries a full water right. The remainder of the area of land within the limits of irrigation from the canals is classified as suspended lands, rights-of-way, or excluded class 6 (permanently nonarable). The suspended lands are classified into nine categories dependent upon the conditions of the individual tracts. Prior to 1939 the SCC land in New Mexico was 88,000 acres. In 1939, by agreement between the irrigation districts and the U. S. Government, the area of SCC land in the project was increased by 3 percent in order that the collection of assessments, allowing for delinquencies, would equal that needed for payment of construction charges. The total SCC classified land in New Mexico in 1946 was 90,623 acres, the total suspended land, 10,985 acres, and the total excluded class-6 land, 547 acres.

The classifications of the valley lands in 1947, as obtained from the Bureau of Reclamation, are given in the following table:

Classification of lands in the Rincon and Mesilla Valleys in 1947

Classification	New Mexico (acres)	Texas (acres)	Total (acres)
Land subject to construction charges......	90,616	10,782	101,398
Riverbed (between levees).................	10,304	857	11,161
Rights-of-way..............................	7,120	1,175	8,295
Suspended lands............................	11,526	1,017	12,543
Total......................................	119,566	13,831	133,397
Irrigated:[1]			
SCC land...................................	....	....	96,089
Suspended lands............................	....	....	5,635
Total......................................	....	....	101,724

[1]Irrigated land included in the total 133,397 acres above.

The classification is given for 1947 in preference to 1946 as the Bureau of Reclamation included in its compilation for 1947 some riverbed areas and additional right-of-way areas not previously reported. The total area of irrigated lands, suspended lands, and class-6 lands was essentially the same in 1947 as in 1946. Because of the inclusion of additional right-of-way and riverbed areas, the total area shown for New Mexico in 1947 (about 120,000 acres), more nearly represents the total area of the New Mexico part of the flood plain of the Rincon and Mesilla Valleys than that given in 1946 (about 112,000 acres). However, the figures for 1947 do not include some water-consuming valley lands that lie outside the boundaries of the irrigation district, such as the Selden Canyon area; areas outside the limits of the canal system; and other areas of rights-of-way and riverbeds not at present determined.

For comparative purposes and in order to get a more detailed picture of the areas of land having various classifications, the following table has been taken from table C of the report of the Rio Grande joint investigation (National Resources Committee, 1938, p. 420-421).

Irrigated lands and other water-consuming areas in the Rincon and Mesilla Valleys, in 1936, in acres

	Total area mapped (acres)	Lands given water artificially				Other water-using areas				Native vegetation			Water areas	
		Irrigated in 1936	Temporarily in need	Cities, towns, and villages	Total area irrigated	Native vegetation	Water and river bed	Total non-irrigated	Bare lands, roads, rights-of-way, and others	Grass	Brush	Trees, bosque	Pooled water	River and canal surfaces
Elephant Butte Irrigation District	124,494	87,464	7,362	1,404	96,230	18,604	6,251	24,855	3,409	3,269	8,343	6,992	47	6,204
Rincon Valley	27,914	15,206	2,129	110	17,445	7,310	2,665	9,975	494	1,010	2,672	3,628	47	2,618
Mesilla Valley (N. Mex.)	96,580	72,258	5,233	1,294	78,785	11,294	3,586	14,880	2,915	2,259	5,671	3,364	....	3,586
Mesilla Valley (Tex.)	13,838	10,665	336	229	11,230	1,904	495	2,399	209	474	1,262	168	4	491
Mesilla Valley (N. Mex. and Tex.)	110,418	82,923	5,569	1,523	90,015	13,198	4,081	17,279	3,124	2,733	6,933	3,532	4	4,077
Rincon and Mesilla Valleys (N. Mex., and Tex.)	138,332	98,129	7,698	1,633	107,460	20,508	6,746	27,254	3,618	3,743	9,605	7,160	51	6,695

The areas included in the two foregoing tables are not strictly analogous because of the omission of various areas in the 1947 tabulation as given above. A difference of about 5,000 acres for the total valley acreage in New Mexico is evident. The total of 138,000 acres probably is nearly equal to the area of the valley floor of the Rincon and Mesilla Valleys in New Mexico and Texas and is the maximum area from which water in the valleys can be transpired or evaporated to the atmosphere.

For the purpose of collection of charges, the lands in New Mexico are under the Elephant Butte Irrigation District and those in Texas under the El Paso County Water Improvement District. These districts are under contract with the United States to repay construction costs of the project and to advance funds for operation and maintenance of the irrigation system.

GEOLOGY

A detailed study of the geology of Dona Ana County was not made during the course of this investigation. The reader is referred to published reports on this area, the most complete and comprehensive of which is that by Dunham (1935). Included in the report by Dunham is a geologic map of Dona Ana County based on that by N. H. Darton as revised by Dunham. An account of the geology of the county by Dunham is also included. A general discussion on the geology of the Rio Grande depression is given by Bryan (1938, p. 197-225). The geology of La Mesa is discussed briefly by Sayre (Sayre and Livingston, 1945).

The most important deposits of the area, with respect to the occurrence of ground water, are the unconsolidated and partly consolidated sediments of Tertiary and younger age that cover the major part of the county. The deposits consist of varying proportions of clay, silt, sand, and gravel that partly fill the deep rock troughs between the mountains. These deposits can be separated into the older, slightly consolidated sediments that make up the greater part of the fill underlying La Mesa and the Jornada del Muerto and the younger unconsolidated deposits locally mantling the underlying older deposits.

The older sediments are generally referred to as the Santa Fe formation and were probably deposited during late Tertiary (Miocene and Pliocene) time (Sayre, and Livingston, 1945 p. 37, 39; Dunham, 1935 p. 175, 176; Bryan, Kirk, 1938, p. 205). The younger sediments were deposited in the Quaternary period during the Pleistocene and Recent epochs (Sayre and Livingston, 1945, p. 37), and they overlie the Santa Fe formation as outwash fan deposits, mainly on the surface of La Mesa and the Jornada del Muerto, and as alluvium deposited by the river in the valleys during successive periods of scour and fill.

As the Santa Fe formation and the younger sediments were deposited and eroded from the same general rock formations by meandering streams and arroyos, they, as a consequence, have the same general character, and as they are nonfossiliferous it is not always possible to differentiate between them.

CHARACTER OF SEDIMENTS

The older, slightly consolidated deposits of the Rio Grande consist of alternate layers and lenses of variable thickness of clay, silt, sand, and gravel. The lateral extent of the layers is likewise quite variable, and these thicken or pinch out in short distances. In the Mesa well field in El Paso, individual beds of the bolson sediments found in 45 wells drilled at intervals of 300 feet in two lines 300 feet apart could not be correlated between more than 2 or 3 adjacent wells (Sayre and Livingston, 1945, p. 28).

In wells 1, 3, and 5, of the city of Las Cruces, which are within a radius of about 150 feet, the available logs (see table 6, p.143) show very little correlation of individual beds. The lack of similarity in these wells is due, in part, to the fact that different drillers do not identify like formations alike. However, city wells 3 and 5 were put down by the same driller, though an interval of about 9 years occurred between the drilling of the wells.

The available logs of three Agricultural College wells, 23. 2E. 29. 243, 243b, and 243c (see table 6, p.143), which are within a radius of about 30 feet, show very little correlation, except possibly for the layer of fine sand at a depth of about 80 to 150 feet. The hard dark formation penetrated in well 23. 2E. 29. 243c from 182 feet to 282 feet does not seem related to the sand, gravel, and clay at a corresponding depth in well 23. 2E. 29. 243.

The sediments that underlie the pediments west of the Rincon Valley, particularly those from near Arrey northward to Truth or Consequences, apparently contain clay layers that in places extend westward for several miles. Direct correlation of beds is lacking, but the artesian wells drilled in the floors of 3 tributaries to the Rio Grande from the west, Mud Springs Draw, Animas Creek, and Percha Creek[4], give indirect evidence of continuous clay layers. In the well of O. B. Dawson, 16. 5. 23. 300 (see table 12, p. 164), which is drilled in the floor of Percha Creek about 1. 5 miles west of Caballo Reservoir, flowing water is obtained at a depth of 160

[4]Murray, C. R., (in preparation) Ground-water conditions in the nonthermal artesian water basin south of Hot Springs, Sierra County, N. Mex.: (New Mexico State Engineer bienn. rept.)

feet, the flow increasing with depth to the bottom of the well at 226 feet. The clay layers may be more extensive in the tributaries than in the pediments because of deposition of sediments by flood flows in the arroyos. However, evidence of some continuity of clay beds in the Santa Fe formation west of Arrey is given by the water level in well 17.5.10.442. This well was drilled on the pediment, about 100 feet from its edge, at an elevation of approximately 40 feet above the floor of the adjacent Montoya Arroyo. The water level in the well, which is uncased and 207 feet deep. is about 16 feet below the surface of the pediment and about 25 feet above the floor of the adjacent arroyo.

The character of the Santa Fe formation is given by the drillers' logs in table 6 (p.143 to 161) and by the following section (Sayre, and Livingston, 1945, pp. 32, 33).

Section of La Mesa in railroad cut half a mile west of Anapra, Dona Ana County, N. Mex.

	Feet
Sandy soil, reddish-buff, partly removed.	
Caliche hard, dense, white, grading downward into very fine gray sand	7
Sand, light-gray, moderately fine, uncemented and containing some layers of gravel with igneous rock pebbles derived mostly from lava flows	5
Clay, brown, sandy	1
Quartz sand, medium-grained, mixed with white pellets of calcium carbonate	.5
Sand, medium- to coarse-grained, salt-and-pepper colored	6
Clay, brown to gray, sandy	2
Sand, crossbedded, light-gray, medium- to coarse-grained, contains some coarse gravel	45
Sand, light-buff, fine-grained, massive, clayey, containing irregular lenses of clean sand. Near the base are numerous tubes of sand cemented with calcium carbonate	9
Sand, extremely fine-grained, gray, with layer of coarse sand near middle	14
Clay, gray, much disturbed and broken	1.3
Sand, medium-grained, gray, containing near the base laminated layers of alternating black and white sand	30
Sand, light-buff, clayey, crossbedded	1.5
Sand, medium-grained, loose, gray	6
Sand, buff to gray, fine-grained, crossbedded; contains pellets of clay and caliche on the bedding planes	2.5
Sand, mostly covered	25
Clay, light-buff, and sandy clay	6
Sand, fine-grained, light-gray, crossbedded	5
Clay, laminated, light-buff, and sandy clay	2.5

Sand, fine-grained, gray, crossbedded	3
Clay light-buff, massive	2.5
Sand, massive, fine-grained, cemented, yellowish-buff, grading into less-cemented gray sand near base and partly covered	30
Clay, chocolate-brown, and light-buff massive sandstone interbedded	11
Sand, brown, crossbedded, partly covered	10
Clay, buff to chocolate-brown, silty	9
	234.8

The Pleistocene and Recent unconsolidated sediments in the valley are predominantly sand and gravel with some thin beds of sandy clay. They are generally very loose and cause trouble in wells by running into them.

THICKNESS OF SEDIMENTS

The maximum thickness of the sediments of the Santa Fe formation in Dona Ana County is not known, but unconsolidated sediments are reported in wells of depths as low as 1,330 feet. A few comparatively deep wells have been drilled. The deepest well reported is the oil test of the Picacho Oil and Gas Syndicate, 23.1.15.211, an abbreviated log of which is given in table 6 (p. 143). This well was drilled on La Mesa, west of Las Cruces, about 1 mile from an outcrop of rock that forms part of Picacho Mountain. The log apparently shows about 550(?) feet of Tertiary or younger sediments at this location.

Near the southern part of La Mesa the Southern Pacific Co. drilled a well (28.2E.24.110), at Strauss to 1,330 feet, entirely through unconsolidated sediments. The Lippincott well, 28.3E. 25., in the lower part of Mesilla Valley is reported to have been drilled in limestone at 822 feet (Sayre and Livingston, 1945, p. 35).

The well of Edwin Parker, 21.2E.12.222, on the Jornada del Muerto about midway between the San Andres and the Dona Ana Mountains was drilled to 631 feet. Limestones and sandstones predominate below 474 feet and the well ends in 80 feet of limestone. The limestone may be similar to the limestone that dips westward beneath the sediments from the west side of the San Andres Mountains.

Valley-fill deposits west of the Rio Grande, north of the Rincon Valley, are believed by Murray[5] to extend to depths in excess of

[5]Murray, C. R., op. cit., p. 25.

2,100 feet, as shown by a well drilled to that depth in the Palomas River, about 10 miles north of Caballo Dam.

The well on the Stahman Farms, 24.1E.1.111, in the Mesilla Valley near Mesilla, apparently was still in the Santa Fe formation at 331 feet.

The thickness of the flood-plain deposits of the Rio Grande constitutes an unsolved problem, according to Bryan. He states that in periods of high water the river is capable of transporting gravel that at ordinary times is unknown in the riverbed; thus the depth to gravel in the riverbed may be taken as a rough measure of the depth of scour in great floods. He states, "It seems probable that there is in the larger valleys [of the Rio Grande] from 100 to 250 feet of relatively recent deposits of flood-plain type above the Santa Fe formation." (Bryan, 1938, p. 218.)

As the Mesilla Valley is constricted at both the upper and lower ends by consolidated rocks that are exposed, it seems logical that rock lies at comparatively shallow depths in those areas. The well of Isaac Rhodes, 21.1.13.323, at the upper end of the Mesilla Valley and at the edge of an arroyo on the east side of the valley, was drilled in "rock" from 93 feet to the bottom of the well at about 215 feet. This rock may be similar to the igneous rocks of the Dona Ana Mountains on the east and to those that crop out in the valley at Leasburg Dam about 1½ miles north of the well. "Rock" was reportedly struck at about 125 feet in the well of C. C. Rice, 21.1.11.431, which is located on the pediment at Fort Selden about 50 feet above the valley and about three-quarters of a mile south of the rock outcrop at Leasburg Dam. In the lower end of the Mesilla Valley, the maximum depth of the fill in the gorge of the Rio Grande at the narrows above El Paso has been shown by Slichter (1905, p. 1, fig. 2) to be not more than 86 feet.

The thickness of Quaternary fill near the central part of the Mesilla Valley, on the basis of the reported log of well 24.1E.1.111, appears to be about 104 feet, as most of the gravel was encountered above this level. However, on the basis of gravel reported in the log of the railroad well at Las Cruces, 23.1E.13.244, the thickness of the Quaternary fill there appears to be about 220 feet.

In the Rincon Valley, available well logs show that clay is present at comparatively shallow depths below the Quaternary alluvium. This clay, which is usually called "heavy red gumbo" or "joint clay" by the drillers, is reportedly dry and is thought by the drillers to have considerable thickness. According to Jeff Chandler, well driller at Mesilla Park, a well was drilled at Hatch in the early years to a depth of 1,100 feet, and nothing but clay was found below about 80 feet. Water was obtained only in the sand and gravel above 80 feet. No substantiating data were obtained on this well. No other wells were reported drilled to this depth in the Rincon Valley. The drillers consider it useless to try to drill through this clay. As water is available in the shallow alluvium in sufficient quantities for all needs, the only incentive for drilling wells through the clay is the hope of obtaining water of better quality for domestic use. In the following table the wells for which data were obtained are listed in order downstream in the Rincon Valley showing the depth at which clay was found.

Reported depth to clay in wells for which data were obtained in Rincon Valley

Name	Well location no.	Total depth of well (feet)	Depth to clay (feet)	Reported description of clay
Osborn	16.5.25.343	152	128	Soft red rock.
Powers	17.5.24.333	101	73	Red gumbo clay.
Plemmons	17.5.26.212	68	68	Clay.
Welch	17.5.26.242	88	84	Clay.
Black	17.5.25.123	59	59	Joint clay.
Black	17.5.25.134	64	64	Clay.
Luchini	17.4.31.111	71	66	Red and white clay with gray sand.
Cantrell	17.4.30.133a	97	70	Red and white clay.
Hedgecock	18.4.9.130	100	50	Blue clay.
Engler	18.4.17.312	70	65	Clay.
Simms	18.4.34.211	245	70	Clay.
Franzoy	18.4.35.231	68	56	Clay.
Franzoy	18.4.35.310	230	60	Clay.
Boggs	18.4.35.221	214	114	Red-brown clay.
Oliver	19.4.3.234	68	68	Clay.
Cowan	19.4.11.221	74	70	Heavy red clay.
Village of Hatch	19.3.9.121a	70	68	Clay.
Cocks	19.3.10.333	69	69	Clay.
Smallwood	19.3.15.443	53	46	Heavy red clay.
Gary	19.2.26.300	150	55	Red clay.

Drilling of most of the wells was stopped as soon as the drillers definitely recognized clay. A few wells were drilled deeper with the hope of going through the clay. The deepest well reported was that of Mr. Simms, which was drilled in clay from 70 to 245 feet, except for a rock about 2 feet thick at about 110 feet. Of the 20 wells listed in the table, 18 reported clay at depths from 46 to 84 feet. The Osborn well, with clay at 128 feet, is located in the floor of Percha Creek about 40 feet above river level. With the exception of the Osborn, Powers, Plemmons, and Welch wells, all are located on the valley floor. The average depth to clay in the 16 wells on the valley floor is less than 70 feet. The thickness of the Quaternary alluvium in the Rincon Valley thus appears to be fairly uniform and somewhat thinner than in the Mesilla Valley.

OCCURRENCE OF GROUND WATER IN UPLAND AREAS

In order to establish the depth to water and the direction of flow of the ground water under the upland area in Dona Ana County adjacent to the Mesilla Valley, as much information as possible on the existing wells was obtained by G. R. Chenot in 1947. The depth to water was measured in many wells and the altitude of each well was determined by use of the aneroid barometer and the U. S. Geological Survey topographic quadrangle maps. Other available information such as the depth of the well, productiveness, materials penetrated, and quality of the water, was obtained generally from the owners. Water samples for chemical analysis were obtained from various wells. Measured depths to water were checked against reported depths in order to judge the reliability of reported depths in wells where measurements were not possible.

Topographic quadrangle maps of the U. S. Geological Survey covering 15 minutes of latitude are available for all the area of Dona Ana County from the Mexican border northward to latitude 32° 30' N. They have a contour interval of 25 feet, with the exception of the quadrangle maps between the Mexican border and latitude 32°00' N. and between longitude 106° 30' and 107°15' W., which have a contour interval of 10 feet. Vertical and horizontal control in the area covered by the quadrangle maps was excellent. The elevations of the wells north of the Dona Ana Mountains, on the Jornada del Muerto, were obtained by using an aneroid barometer and are subject to some error as the distance between bench marks and check points was great and resulted in a comparatively long time interval between readings. However, the elevations of sufficient check points were read on different days to eliminate any large errors.

The resulting ground-water contours are shown on the accompanying map, plate 1. In drawing the contours greatest reliance was naturally placed upon the wells in which the depth to water was measured. With these measured depths to water as controls, the contours were drawn for the other areas, the elevations of the water table being calculated from reported depths to water as guides, more reliance being placed upon some than others. The areas showing various depths to water were defined by subtraction of the ground-water contours from the ground-surface contours and are therefore as accurate as the water-table contours.

DEPTH TO WATER

The depth to water in the upland areas in Dona Ana County ranges from less than 25 feet to more than 400 feet. Generally the areas of greatest depth to water, more than 300 feet, are in the relatively flat plains away from the mountain fronts, such as the La Mesa surface in T. 26 S., R. 1 W. The depth to water generally decreases toward the east side of the Jornada del Muerto and the west side of La Mesa, where the aquifer is relatively thin and the buried rocks of the mountains that form the floor of the aquifer rise, thus holding the water at a higher level than in areas farther from the mountains. The depth to water may therefore be very shallow in the arroyos along the mountain fronts where the deposit of alluvium is thin.

In the Jornada del Muerto, north of the Dona Ana Mountains, the depth to water ranges from 200 to 300 feet below the surface in the western half of the Jornada Experimental Range. A little farther east the depth to water apparently increases to between 300 and 400 feet in a narrow north-south strip and then gradually decreases eastward toward the San Andres Mountains. Northwest of the Dona Ana Mountains the depth to water is about 200 feet and it decreases westward to less than 25 feet near the Rio Grande.

In the Jornada del Muerto, south of the Dona Ana Mountains and east of Las Cruces, the depth to water gradually increases from less than 25 feet at the eastern edge of the Mesilla Valley to more than 400 feet in a narrow north-south strip about 8 miles east of the valley. Farther eastward toward the Organ Mountains the depth to water decreases and is generally from 100 to 200 feet in the vicinity of Organ.

At the southeastern edge of the Sierra de las Uvas, west of the Mesilla Valley, the depth to water is less than 25 feet. Southeastward the depth to water gradually increases to more than 400 feet in a strip about 4 miles wide roughly paralleling the eastern side of the Aden and the Sleeping Lady Hills, and in an area of La Mesa west of Black Mountain near Afton. Farther east the depth to water decreases to about 300 feet along the top of the bluff that parallels the western side of the Mesilla Valley. From the top of the bluff eastward to the valley, a distance of about 2 miles, the depth to water decreases rather abruptly from about 300 to less than 25 feet.

The depth to water, as projected in some areas on the map (pl. 1), is probably greater than the thickness of the sedimentary deposits where masses of igneous rock occur at or near the surface. In such areas water will not be obtained if the rock is impermeable. Some wells on the Bissell ranch have been drilled to a depth greater than the indicated depth to water but have failed to obtain sufficient water for stock purposes. Some of the lavas near Afton occur at the surface above the sediments (Sayre and Livingston, 1945, p. 24). In this area water may be found below the lava at the indicated depth to water. If intrusive sills or other impermeable igneous rocks occur at the indicated depth to water, drilling below the impermeable beds will probably reach confined water, which will rise in the well to the indicated water level.

The well on the Corralitos ranch, 23. 1. 32. 330, which was drilled to 501 feet, reportedly penetrated an igneous flow or sill from 165 to 320 feet, a sandstone from 320 to 430 feet, and a rust-colored sand from 430 to 501 feet. The estimated depth to water as reported was 350 feet but, as indicated on the map, is probably a little less than 400 feet. The Malpais well, 26. 1. 16. 330, on the Braidfoot ranch was drilled in a sink in the lava to a depth of 445 feet and reportedly reached water in sand and clay below the lava at 406 feet. The Aden station well of H. S. Bissell, 25. 3. 2. 220, on a small rise, reportedly was drilled through about 440 feet of red igneous rock to seeps of water yielding about 15 gallons a minute at 440 feet. The reported depth to water is 444 feet.

Other wells also have probably obtained water below lava, but data on many of the wells are scant.

Data on the depth to water obtained during this investigation differ from those reported by Lee (1907, p. 38-40). The following table gives the depths to water in various wells as reported by Lee and as collected from various sources during this investigation.

The difference in depth and water level as shown for well 29. 1E. 6. 110 for early and present dates may possibly be due to comparing different wells in the same locality, or may be due to inaccurate reporting. Actual changes in water level may have occurred. The water levels show a rise from the time reported by Lee to later dates. The Lanark well 1 shows a fall in water level from 1899 to the time reported by Lee. On the data for this well one could postulate that water levels declined from early years to a low level in the year reported by Lee and then rose again. However, as all depths to water reported by Lee are lower than those obtained for the same wells from other sources, there may be a consistent error. It is not known how many, if any, of the depths to water reported by Lee were measured by him or were values reported to him. The apparent rise in water levels is greater than one would expect to find in static levels under an area such as La Mesa where the annual rainfall is small. It therefore appears that the reported values are somewhat unreliable.

Comparison of water levels in Dona Ana County, N. Mex., at different times and as reported from different sources

Well location no.	Field name	Owner or name	Source of information	Date of reported water level	Depth of well (feet)	Depth to water (feet)	Apparent difference in water level, earliest to latest report (feet)
21.2E.25.430a	....	J. D. Isaacs.	Lee, W. T. (1907, p. 38)	1905 (?)	330	292	
Do.	....	W. F. Isaacs.	Owner and measurement.	1947	325	290.5	+1.5
22.1.19.330	....	Mr. Hawkins.	Lee, W. T. (1907, p. 40)	1905 (?)	218	170	
Do.	Hawkins	H. S. Bissell.	Owner and measurement.	1947	180	151.0	+19
27.1E.11.330	Lanark well 1	Southern Pacific Co.	Railroad log 3049	1899	950	365	
Do.	do.	do.	Lee, W. T. (1907, p. 40)	1905 (?)	945	380	-15
27.1.26.430	....	J. B. Stahling.	do.	1905 (?)	350	311	
Do.	Phillips Hole	Mrs. Annie Braidfoot.	Owner and measurement.	1947	314	286.9	+24
28.2E.24.110	Strauss well 1	Southern Pacific Co.	Railroad log 3084	1917	950	342	
Do.	do.	do.	El Paso office file	1941	950	340	+2
28.2E.24.110a	Strauss well 2	do.	Railroad log 3085	1918	705	342	
Do.	do.	do.	El Paso office file	1941	705	330	+12
28.2E.24.110b	Strauss well 3	do.	do.	1945	550	328	+14
28.2E.31.340	....	R. A. Gardner.	Owner.	1910-20(?)	400	325	
Do.	....	do.	Measurement.	1947		392.5	+32.5
29.1E.6.110	....	Robert Herrington.	Lee, W. T. (1907, p. 40)	1905 (?)	435	350	
Do.	....	Herrington ranch.	R. A. Gardner.	1947 (?)	400	265	+85 (?)
29.1E.8.210	Noria well 1	Southern Pacific Co.	Lee, W. T. (1907, p. 40)	1905 (?)	438	358	
29.1E.8.210a	Noria well 2	do.	Railroad log.	1914	565	321	+37 (?)
29.1E.8.210b	Noria well 3	do.	do.	1916	560		

MOVEMENT AND FLOW OF GROUND WATER

The contours of the water table on the accompanying map (pl. 1) connect points of the water table having equal altitude. The direction of flow of the ground water is perpendicular to the contours, from higher to lower elevations. The flow of ground water in a homogeneous aquifer of constant width and thickness is proportional to the gradient or slope of the water table—that is, to the spacing of the contours.

The general direction of flow of the ground water in the upland areas of Dona Ana County is from the higher elevations toward the lower along the Rio Grande. The movement of some of the ground water, however, is quite circuitous.

North of the Dona Ana Mountains, in the Jornada Experimental Range, ground water flows westward from the San Andres Mountains and is joined by ground water from the Jornada del Muerto to the north and from the eastern slope of the hills on the east side of the Rio Grande. This water is indicated as flowing through a gap north of the Dona Ana Mountains into the Rio Grande in the vicinity of Leasburg Dam, near Fort Selden.

A ground-water divide evidently occurs in the broad saddle formed between the Dona Ana Mountains and the San Andres Mountains, so that the ground water on the northern slope flows toward the Jornada Experimental Range and that on the southern slope flows to the river in the vicinity of Las Cruces. Ground water originating west of the Organ Mountains flows westward to the Mesilla Valley.

Ground water originating from runoff on the east side of the Sierra de las Uvas flows to La Mesa through the gap between Sleeping Lady Hills and Rough and Ready Hills, T. 22 S., R. 2 W., and through the gap between Sleeping Lady Hills and the Aden Hills, Tps. 23 and 24 S., R. 2 W. The ground-water contours suggest that a ground-water divide occurs in T. 21 S., R. 2 W., and a small part of the ground water on the east side of the Sierra de las Uvas may flow northeastward to the Rio Grande through alluvial fill in canyons and arroyos.

Ground water that originates to the west and south of Robledo Mountain in part finds its way to the Rio Grande in the vicinity of Las Cruces. A ground-water divide probably occurs between Robledo Mountain and the Rough and Ready Hills, about 4 miles to the west, and thus a small part of the ground water probably reaches the Rio Grande northward by way of Faulkner Canyon.

Most of the ground water that originates from precipitation on La Mesa south of T. 23 S. and that which flows through the gap between the Sleeping Lady Hills and the Aden Hills flows southward on the west side of Black Mountain, where it is joined by ground water from the east slope of the Potrillo Mountains, and then moves eastward to enter the Rio Grande near Strauss.

Lee (1907, p. 39-40), on the basis of reported water levels in the wells owned by the railroad at Lanark and Noria on the La Mesa surface north of the Mexican boundary, stated that the water table sloped southward 20 feet in 12 miles or 1.7 feet to the mile and presumably, therefore, ground water flowed southward from the Rio Grande and La Mesa to Mexico. Lee (p. 40-50) recognized that his meager data indicated a flow southward but, because of the downcutting of the river that formed the Mesilla Valley and the accumulation of water in the gravels of La Mesa, he believed that the underflow down the probable old channel of the river on La Mesa had been reversed and that the ground water flowed into the valley. As Slichter (1905, p. 9-13) had demonstrated that very little ground water escaped from the Mesilla Valley through the narrows at El Paso, Lee showed that the more probable escape of both the water moving from La Mesa to the valley and the water lost from the river in the valley was by evaporation in the valley.

Information gathered during this investigation confirms Lee's belief that ground water does not flow southward under La Mesa to Mexico but rather, from the Mexican boundary, between the East Potrillo Mountains and the Rio Grande, northward and eastward to the Rio Grande. Conflicting data gathered on various wells in this area do not indicate that there is an appreciable change in the configuration of the water table, shown on plate 1.

The depths to water in the Lanark and Noria wells, as recorded in well logs obtained from the railroad, are 365 and 321 feet, respectively, and the altitudes of the wells, as reported by Lee, are 4,156 and 4,114 feet, respectively. Thus the water table is shown as being 2 feet higher at Noria than at Lanark. If altitudes of 4,170 and 4,124 feet at Lanark and Noria, as determined from the topographic quadrangles, are used with the depths to water as recorded in well logs obtained from the railroad, then the water table at Noria is 2 feet lower than at Lanark. Even if the data as reported by Lee, which show the water table 20 feet higher at Lanark than at Noria, are assumed to be correct, it does not necessarily follow that the ground water flows southward, as a ground-water trough lies between Lanark and Noria. (See pl. 1.)

If the depth to water in the Herrington ranch well, 29.1E.6.110, reported by Lee to be 350 feet, and that in the well at Noria, 29.1E.8.210, 358 feet, are considered correct, then a low spot is indicated in the contours of the water table that would shift the 3,800-foot contour to the west of Noria. However, the water level measured in 1947 in well 28.2E.31.340 does not allow an appreciable change in the shape of the contours. It is probable that a ground-water divide occurs just south of the international boundary, in the area between the East Potrillo Mountains and the Cerro de Muleros, similar to that indicated in the vicinity of Mount Riley and Malpais sidings.

A ground-water divide occurs between the Sierra de las Uvas and the West Potrillo Mountains. West of R. 3 W. the ground water apparently flows westward into the topographic basin east of the Florida Mountains in Luna County, and thence southward east of Columbus, N. Mex., into Mexico.

The ground water west of the Rincon Valley in the area traversed by Placita Arroyo is shown as flowing toward the Rio Grande in the vicinity of Hatch. Wells in this upland surface are too widely scattered to indicate the exact slope of the water table or the exact direction of flow.

The water-table contours on the water-level map of Dona Ana County (pl. 1) show that the Rio Grande gains water in the Mesilla Valley from the upper part of the valley almost to Mesilla, loses water from Mesilla to Vado, and again gains water south of Vado. The contours were generally drawn through the corresponding riverbed elevations shown on the topographic maps, which may not be the altitude of the water table under the river. If the river water is not in direct contact with the water table, then the river must be perched and must lose water to the water table. In such a case, contours drawn to the river level would show a mound, and therefore indicate correctly that the river is losing water. In the section where the river is shown to be losing water the loss is probably to the paralleling drains, the true contours being inflected somewhat more sharply than can be shown on the scale of the map. The loss or gain in the river is discussed more fully in the section on sources of ground water in the valley fill.

The gradient of the water table under the upland surfaces ranges from about 1.2 feet per mile in the trough of the water table under La Mesa to the west and south of Black Mountain to more than 100 feet per mile on steep slopes along the mountains, such as on the east side of the Aden Hills and West Potrillo Mountains. The average slope of the water table in the Mesilla Valley, as shown by the water-table map of Dona Ana County from the 3,900-foot contour north of Las Cruces to the 3,750-foot contour near the southern end of the valley, is about 4 feet to the mile, essentially the same as that of the river.

The range of gradients is due to various factors, which include width, thickness, and permeability of the formations, and the quantity of ground-water flow. The steep gradients along the slopes of the mountains are due primarily to the thinness of the water-bearing formation that lies upon the steep slopes of the relatively impermeable rocks that compose the mountains. The gradients in themselves do not indicate the volume of flow of the ground water.

The relatively steep gradient of the water table, about 30 feet to the mile, shown by the contours that extend from the southern end of Robledo Mountain southwest to the West Potrillo Mountains, may be caused by a connection underground of igneous or other relatively impermeable rock between the hills in this area, acting as a "ground-water dam," water on the west thus being held at a higher level than that east of the hills. Southeastward the gradient flattens to about 13 feet to the mile between the 3,800- and 3,900-foot contours in T. 25 S., R. 1 W., and to about 1.2 feet to the mile in the water-table trough west of Black Mountain.

The progressive flattening of the gradient of the water-table in the direction of flow from the gap between the Aden and Sleeping Lady Hills to the Rio Grande east of Strauss is caused by an increase in the width, thickness, or permeability of the saturated aquifer, by a decrease in amount of ground-water flow, or by a combination of these factors. Undoubtedly, the thickness of saturated sediments increases in the direction of flow. The saturated aquifer along the east side of the Aden and Sleeping Lady Hills is presumably thin, as the hills protrude through the sediments. The thickness of the sedimentary deposits of La Mesa is not known. Apparently the deepest well, the 1,330-foot well at Strauss, penetrated only unconsolidated deposits (Sayre and Livingston, 1945, p. 35). The bolson deposits in the Hueco Bolson east of the Franklin Mountains seems to be at least 4,000 feet thick (Sayre and Livingston, p. 33).

The width of the saturated aquifer, however, does not increase but, instead, decreases from a width of about 12 miles east of the Aden Hills to about 3 miles in the ground-water trough west of Black Mountain. The sediments underlying the central portion of La Mesa may be more permeable than those along the slopes of the hills. This is probable if the central part of La Mesa is composed of sediments deposited by the Rio Grande, which flowed at one time through the Jornada del Muerto and La Mesa, as postulated by Lee (1907, p. 22). Undoubtedly, the amount of ground-water flow does not decrease in the direction of flow as there is no area of surface discharge of the ground water. Instead, the amount of ground-water flow probably increases eastward because the ground-water trough also carries water from the east slope of the Potrillo Mountains.

Therefore, the decrease in gradient of the water table from northwest to southeast across La Mesa is due to the increased thickness, and possibly to the increased permeability, of the saturated sediments, which more than offset the increase in amount and the decrease in width of flow of the ground water.

The amount of water flowing eastward from R. 1 E. to R. 2 E. toward the Rio Grande, between the two 3,800-foot contours south of Lanark, can be roughly calculated. The average coefficient of transmissibility of the aquifer may be taken as 70,000 gallons a day per mile of width of the aquifer for each foot per mile of slope of the water table, approximately equal to that of 73,000 determined by the pumping test of Las Cruces city well 5 (p. 96). With a gradient of 1.2 feet per mile and a width of about 9 miles, the ground-water flow to the Rio Grande in the vicinity of Strauss is of the order of 750,000 gallons a day or 840 acre-feet a year, a small quantity.

The selected gradient of the water table, 1.2 feet a mile, is an average from the 3,800-foot to the 3,775-foot contour and may be significantly smaller than the actual gradient at the section. The gradient of the water table in the Hueco Bolson, between the 3,700-foot and 3,675-foot contours, east of the Franklin Mountains and northeast of El Paso, is 2.4 feet per mile (Sayre, and Livingston, 1945, pl. 2). The amount of precipitation on the Hueco Bolson is similar to that on La Mesa, and therefore approximately the same average unit amount of recharge probably reaches the water table in both areas. As the deposits are thick in both areas, the steeper gradient in the Hueco Bolson may be due to a lower average permeability of the formation than in La Mesa. However, the gradient of 2.4 feet a mile is small and is given for comparison with that determined in La Mesa. The coefficient of transmissibility used, 70,000, is believed to be rather high as an average for the Santa Fe formation and would tend to offset the probable higher gradient, so that the amount of computed ground-water flow to the Rio Grande in the vicinity of Strauss would not be changed materially.

The annual flow of roughly 800 acre-feet of ground water to the Rio Grande in the vicinity of Strauss, if distributed equally across the 9-mile width of the section, would amount to an accretion to the river from the west of about 0.13 cubic foot a second per mile along the river.

The average gradient of the water table, along the trough in the water table under the central part of the plain northeast of Las Cruces, is about 20 feet to the mile. If the transmissibility of the sediments here is about the same as that determined for city well 5, or about 70,000 gallons a day per mile of width of the formation with a gradient of 1 foot per mile, the flow toward the valley from northeast of Las Cruces would be about 1,400,000 gallons a day per mile of width of the aquifer, or about 2 cfs (cubic feet a second) per mile along the valley. However, the average transmissibility in this area is probably less than 70,000, possibly not more than 30,000, and the ground-water flow to the river from northeast of Las Cruces may be as little as 1 cfs per lineal mile. Slichter (1905, p. 27-29) in his study of the ground waters of the Rio Grande valley, determined in the vicinity of Mesilla Park that about 0.5 cfs was being contributed to the valley from the northeast for each lineal mile.

Flow to each mile of the Mesilla Valley from the remainder of the area east of the valley is expected to be less than that from northeast of Las Cruces because the aquifer is thinner. The amount of water entering each mile of valley from the east may be somewhat greater than that from the west as a result of the greater precipitation on the higher mountains. Arroyos from the highlands to the river are more definitely developed east of the valley than west. The gradient of the water table under most of the area east of the river and south of Las Cruces is not known but may be slightly greater than that northeast of Las Cruces, because of the steepness of the surface from the Organ and Franklin Mountains. The overall average accretion to the valley from the highlands on the east is believed to be less than that northeast of Las Cruces and more than that west of the valley; it is estimated as about 0.7 cfs per mile along the valley.

The flow of the drainage ditches in the Mesilla Valley is composed of varying percentages of return irrigation water, canal seepage losses, and seepage from the river, in addition to some ground-water flow from the side mesas. Presumably, if diversions to the irrigated lands were stopped and there were no flow in the river, the resultant drain flow, if any, would be that contributed by ground water from the side mesas. Figure 3, which shows the relation of reported net diversions in the Mesilla Valley to water being returned to the river by the drains, indicates that with no diversions there would be approximately 5,500 acre-feet a year of drain flow, equivalent to about 0.1 cfs per mile for 55 miles along the valley. This figure necessarily is very rough as it was assumed that a linear relation existed between the diversions and drain flow, which may not be true. Also, the line in the figure is not determined exactly by the points plotted. This small quantity does not necessarily represent the total flow from the side mesas but probably only that part of the side flow that contributes to the drainage ditches, the balance being consumed by vegetation.

The total accretion of ground water to the valley from the highlands on both sides of the Mesilla Valley may therefore amount to less than 1 cfs per lineal mile, less than 40,000 acre-feet a year for the 55 miles of valley. The accretion to the Rio Grande in the 150 miles from Pena Blanca to San Marcial previously has been estimated as nearly 1 cfs per lineal mile (National Resources Committee, 1938, p. 291). The exactness of the value for accretion of ground water from the highlands to the Mesilla Valley is open to question, but the order of magnitude is believed to be right, and it shows the small amount of ground water reaching the valley from the side mesas.

RECHARGE OF GROUND WATER

The ground water in the upland areas of Dona Ana County is derived from precipitation upon the upland and mountainous areas. It seems probable that by far the larger part of the precipitation upon La Mesa evaporates and is transpired by plants and that very little reaches the water table. As most of the rainfall occurs in the form of showers during the summer when the ground surface is very hot and dry, the amount of evaporation is large, and whatever precipitation does get below the ground surface replenishes the soil moisture for use by plants. Only in wet years or periods of protracted wet spells can an appreciable quantity of water be expected to reach the water table from the surface of the plain. H. S. Bissell, of the Corralitos ranch, states that flood water has collected, at times, in the depression southwest of Robledo Mountain, east of Sleeping Lady Hills, forming a shallow lake from 4 to 6 miles in length which lasts from about 1 month to as much as 6 months before disappearing. This long time suggests that most of the water is lost by evaporation and little by downward percolation because of the clay bottom of the depression. The greater part of the recharge in the La Mesa area is probably from precipitation upon the various areas of lava exposed at the surface. A small part of the recharge also probably occurs along the mountain fronts where freshets discharge upon and sink into the plain. It is believed that in the Hueco Bolson, east of the Franklin Mountains, very little recharge to the ground-water body occurs from precipitation upon the floor of the basin, which may collect in sinks, but rather that the major part of the recharge comes from precipitation in the area of gravels along the western edge of the bolson, along the east slope of the Franklin Mountains (Sayre and Livingston, 1945, p. 70-72).

The ground-water flow through an area is in approximate equilibrium with the average amount of recharge that contributes to the flow. The surface area contributing to the flow of about 800 acre-feet a year in the section south of Lanark comprises roughly 26 townships or 600,000 acres. On this basis the average ground-water accretion from precipitation on the area is less than 0.02 inch annually. This small quantity is what might be expected in this area where the annual rainfall is less than 10 inches.

The small amount of precipitation annually recharging the ground water in the La Mesa area, computed above, may be compared with an amount of 0.05 to 0.06 inch contributing annually to the ground-water supply of the High Plains in Texas where the average annual precipitation is about 17 inches. The recharge to the High Plains has been computed on the basis of an estimated natural ground-water discharge of 25,000 to 30,000 acre-feet a year from 9,000 square miles of the High Plains (White, Broadhurst, and Lang, 1946, p. 391).

WATER CONDITIONS IN THE RINCON AND MESILLA VALLEYS

In the Rincon and Mesilla Valleys surface and ground water are closely related. A change in the condition of one is reflected by a change in the other. The surface water and ground water are in approximate equilibrium, the level of the water table and the flow of the drainage ditches being controlled by the losses occurring from the surface supply. Normally the surface water is diverted to irrigate the land, and the seepage that occurs from the irrigated lands, canals, and the river reappears as return flow in the drains and is reused in the lower divisions of the project. Because of the physical connection between the surface and ground waters and because the water in the drains is part of the project water supply, it is not possible logically to discuss the ground-water conditions without also discussing those of the surface water.

SURFACE WATER

AVAILABLE SURFACE FLOW

To evaluate properly the effects upon the supply of surface water caused by pumping ground water in the Rincon and Mesilla Valleys and to arrive at the quantity of water that would have to be pumped for irrigation in case of a shortage of surface water, it is necessary to consider the quantity and the seasonal distribution as involved in the present exclusive use of surface water for irrigation.

The quantity of surface water released to the project has varied widely from year to year, dependent upon the amount of water in storage in Elephant Butte Reservoir. Prior to the completion, in 1938, of Caballo Dam, about 28 miles below Elephant Butte Dam, water released to the project was gaged at the station below Elephant Butte Dam. Since 1938, the water released to the project has been gaged at the station 0.8 mile below Caballo Dam and about 1.5 miles above Percha Dam, the first diversion dam of the project. According to records obtained from the Bureau of Reclamation, there was an average annual accretion of about 27,000 acre-feet from 1925 to 1937, in the section of the river from Elephant Butte Dam to Percha Dam. A seepage run (simultaneous or nearly simultaneous stream gagings made at many places to determine the extent of gains or losses and where they occur) made on the Rio Grande in November 1928 (New Mexico State Engineer, 1928, p. 24) indicates an annual gain in flow by the river in this section of 35,000 acre-feet, and a seepage run made by the State Engineer's office in February 1936[6] indicates an annual gain in flow of 32,000 acre-feet. In order to include this gain in flow in the water supply of the project and to have records comparable to records of water released from Caballo, the data for flow of the Rio Grande at Percha Dam for years prior to 1938 has been used in this report. The table on page 136 gives the annual flow from 1930 to 1946 at Percha and Caballo Dams, at Leasburg Dam, and at the El Paso station along with the streamflow depletion between Percha and Leasburg Dams, corresponding to the Rincon Valley, and between Leasburg Dam and the El Paso station, corresponding to the Mesilla Valley.

The large flow in 1942 was caused by water discharging over the spillway of Elephant Butte Dam, the only time there has been such a discharge. The average annual flow below Caballo Dam from 1930 to 1946, with the exception of the abnormal year of 1942, was 794,200 acre-feet. Of the water released, 60,000 acre-feet per year is required by international treaty for delivery to Mexico; this leaves 734,200 acre-feet minus losses plus return waste, drain flow, and arroyo accretions to be diverted for use in the project. The diversions from the Rio Grande into the Acequia Madre near Ciudad Juarez, for use in Mexico, have averaged 62,500 acre-feet during the period of record, 1938 to 1946 (International Boundary and Water Comm., 1946, p. 51) approximately equal to the required amount.

The monthly distribution of water released from Caballo Reservoir from 1938 to 1946 is given in the table on p. 137. The water releases for the 6 months from April through September account

[6]Bliss, J. H., 1936, Report on investigation of invisible gains and losses in the channel of the Rio Grande from Elephant Butte to El Paso, Tex. (unpublished), table 2, p. 8, February 1936.

for about 84 percent of the demand on the reservoir, not taking into account the abnormal year of 1942. In each year except 1942 the releases for May were smaller than those for April. This decrease in demand in May is characteristic of the project.

DIVERSIONS TO CANALS OF RIO GRANDE PROJECT

The gross annual diversion of water to the canals of the project varies annually, depending upon the release of water from storage. Table 3 on page 138 gives the annual diversions at Percha Dam, Leasburg Dam, Mesilla Dam, to the El Paso Valley of the project, and to the Acequia Madre which serves the Valle de Juarez of Mexico. The water diverted at the Percha Dam to the Arrey Canal serves the Rincon Valley. The water diverted at the Leasburg Dam to the Leasburg Canal and at the Mesilla Dam to the East and West Side Canals serves the Mesilla Valley, the lower part of which is in Texas. Included as diversion at the Mesilla Dam is water wasted from the Leasburg Canal to the East Side Canal. Diversions to the Acequia Madre for the Valle de Juarez are made at the International Dam, and figures for these diversions are available only for the period since the beginning of operation of the American Dam in 1938.

A portion of the gross diversion in each valley is wasted back to the river or to the drainage ditches and is again diverted, along with the return drain water, by the next lower unit. This wastage in a normal year, as discussed in the following pages, is estimated for the period 1930 to 1946 as averaging about 24 percent of the gross annual diversion of 589, 300 acre-feet to the Rincon and Mesilla Valleys. The net annual diversion to the Rincon and Mesilla Valleys is therefore estimated as averaging 447, 900 acre-feet or 61 percent of the 734, 200 acre-feet released from storage from Caballo Dam and available to the project, and the gross annual diversion of 589, 300 acre-feet averages 74 percent of the release from reservoir storage.

DISTRIBUTION OF DIVERSIONS

The distribution of diversions, which include canal wastes and seepage losses, is important not only because the losses contribute to the ground-water body and eventually the flow of the drains but also because the losses must be known in order to determine the quantity of ground water that must be pumped for irrigation in a dry year.

Table 5 (p. 141 to 142) obtained from the U. S. Bureau of Reclamation gives the compilation of irrigated acreage and water distribution by years, 1930 to 1946, for each division of the Rio Grande project and for the project as a whole.

Figures for the irrigated acreage are compiled every year by the U. S. Bureau of Reclamation information furnished by the watermasters of each division and are believed to be reasonably accurate. The headgate diversions are the quantities measured at the heads of the main canals and are also reasonably accurate. Canal waste or return is unused diverted water that is returned to the river or wasted to the drains from the canals. This quantity is estimated daily by the ditch riders and is probably reported low. Water delivered to the farms is, in general, estimated by the ditch riders, a few deliveries during a year being measured with a current meter. It is believed that the reported deliveries are less than actual, as they are conservatively estimated quantities on which payment for water is based.

The acreage irrigated, as shown in the tables, has increased nearly every year for all divisions of the project, with the exception of the early 1930's, when economic conditions were poor, and in 1935, when there was an impending shortage of water. The total acreage irrigated in the project increased from 141,197 acres in 1930 to 159,899 acres in 1946. This increase was brought about mainly by gradual leveling of land formerly too rough to irrigate. The area supporting native vegetation probably has been reduced by this process.

UNIT DIVERSIONS

The average annual diversion of water from the river to the canals in the Mesilla and Rincon Valleys from 1930 to 1946 was about 6.5 acre-feet per irrigated acre. The minimum annual diversion reported for the Rincon and Mesilla Valleys occurred in 1941 with 4.7 acre-feet per acre for the Rincon Valley, 4.8 feet for the Leasburg division, and 5.4 feet for the Mesilla division.

CANAL WASTE

Canal waste or return is of an operational nature and can be reduced by careful attention to water schedules. It is reported that much of the wastage is due to cancellation of water orders by the farmers after the water has already been released from the dam and diverted to the canals. The minimum figure reported for annual canal waste in the Rincon and Mesilla Valleys from 1930 to 1946 was 8 percent of the diversion, occurring in 1946 in the Leasburg division, and the maximum was 35 percent, occurring in 1930 and 1931 in the Rincon Valley and Leasburg division. In general, lower percentages for canal waste have been reported in the later years. The weighted average of the reported wastage for the Rincon and Mesilla Valleys is about 19 percent. As the reported canal wastage is probably low, the actual average canal wastage is estimated as about 24 percent of the gross headgate diversions of 6.5 acre-feet per acre, or 1.6 acre-feet per acre.

CANAL-SEEPAGE LOSSES

The canal and unaccounted-for losses, given in the tables (p. 71 to 72), include seepage losses from the canals, evaporation from the water surface in the canals, transpiration by plants along the banks of the canals, and any other losses. The reported seepage losses are derived by subtracting from the diversions the estimates of the water wasted from the canals to the river or drains and the water delivered to the farms. As both the wastage and the deliveries are believed to be greater than reported, it is probable, therefore, that the actual seepage losses are lower than reported. The lowest figure reported for annual canal losses in the Rincon and Mesilla Valleys from 1930 to 1946 was 26 percent, which occurred in 1937 and 1940 in the Leasburg division.

A seepage run was made in November 1923 by the Bureau of Reclamation upon the Leasburg Canal from Wasteway No. 1, about a mile below the Leasburg Dam station, to Elwood, a distance of 11.59 miles. The stretch of canal was divided into 5 sections in lengths ranging from 0.7 mile to 4.3 miles. The loss of water in the sections ranged from 0.7 cfs per mile to 2.2 cfs per mile, with an average loss for the whole distance of 1.2 cfs per mile. The total length of canals and laterals in the Leasburg system is 115.3 miles. The total indicated loss of water, therefore, is about 138 cfs, about 22 percent of the reported capacity (635 cfs) of the Leasburg Canal near its head.

The percentage of seepage loss from the canals is not constant, either for the whole of the canals or any part of them or for various quantities of flow. The actual quantity of water lost by seepage is more nearly constant. Small quantities of flow will show, in general, a larger percentage of loss than large quantities of flow in the same canal. However, in a normal year the estimated canal seepage and unaccounted-for losses in the Rincon and Mesilla Valleys average about 20 percent of the gross headgate diversions of 6.5 acre-feet per acre, or 1.3 acre-feet per acre.

WATER DELIVERED TO FARMS

The water delivered to the lands in the Rincon and Mesilla Valleys is the remainder of headgate diversions after accounting for canal wastage and seepage losses. Using the figures of 24 percent for canal wastage and 20 percent for seepage loss to be deducted from headgate diversions in an average year, the water delivered to the lands in the past is 56 percent, which in an average year with headgate diversions of 6.5 acre-feet per acre amounted to 3.6 acre-feet per acre of irrigated lands. In contrast, the reported average delivery of water to the land in the period from 1930 to 1946 was only 2.8 acre-feet per acre or about 43 percent of the water diverted from the river. The maximum reported percentage of the diversions delivered to the farms in any one year was 58 percent, in 1937 and 1940 in the Leasburg division. In general, larger percentages have been reported as delivered to the farms in later years.

A rough comparison of the estimated percentages of diversions delivered to the lands in the past, averaging about 56 percent, with what possibly could have been delivered under past conditions can be made by combining the minimum quantities reported in any year for canal wastes and for canal losses in each division and assuming the remainder of the diversion to have been available for delivery to the farms. In the Rincon Valley, the minimum reported percentage for canal waste is 14, in 1946, and for canal losses 29, in 1939 and 1940, making a possible delivery to the lands of 57 percent. In the Leasburg division, the minimum reported percentage for canal waste is 8, in 1946, and for canal losses 26, in 1937 and 1940, making a possible delivery to the lands of 66 percent. In the Mesilla division, the minimum reported percentage for canal waste is 10, in 1946, and for canal losses 30, in 1943, making a possible delivery to the farms of 60 percent. The average for the three divisions is 61 percent, compared with the estimated actual delivery of 56 percent.

FLOW OF DRAINS IN RINCON AND MESILLA VALLEYS

The flow of the drains is directly related to the ground-water levels, which, in turn, are related to the amount and seasonal distribution of the surface-water supply. To show this relationship the seasonal variation of the drain flow must be known, as well as the total annual flow. Also, in order to determine the effect of pumping upon the drains it is necessary to determine the average gain in flow of the drains.

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Drains have been constructed in the Rincon, Mesilla, and El Paso Valleys to maintain the water table at a low level. In 1946 there were about 42 miles of drains in the Rincon Valley and about 226 miles of drains in the Mesilla Valley. The rate of flow in the drains is measured about three times a month with a current meter at the outlet of each drain, except the two short intercepting drains in the Mesilla Valley, the Santo Tomas and Montoya, totaling about 8½ miles, which are not measured. The monthly and annual drain flow for the Rincon Valley and the Mesilla Valley, from 1930 to 1946, are given in table 5 on pages 141, 142. On the average, about 64 percent of the drain flow occurs in the 6 months from April through September, as contrasted with 84 percent of the release from storage in the same period. The average annual drain flow for the Rincon and Mesilla Valleys from 1930 to 1946 is 249,400 acre-feet, or about 42 percent of the gross diversions and 52 percent of the gross diversions and 52 percent of the reported net diversions—that is, gross diversions minus wastage—to the Rincon and Mesilla Valleys in the same period.

The average return flow of the drains for the Rincon Valley is 50 percent of the reported net diversion to that valley, and the return flow of the drains for the Mesilla Valley is 52 percent of the reported net diversions to that valley. The close agreement between the percentages of return flow of the drains for the 2 valleys indicates a similarity of conditions.

With a normal supply of surface water the average monthly gain in flow of the drains in cubic feet per second per mile of drain, in the Rincon Valley ranges from a minimum of about 0.6 in January to a maximum of about 1.7 in August, with an average of 1.2 for the year; in the Mesilla Valley it ranges from a minimum of 0.8 in February to a maximum of 1.9 in August, with an average of 1.3 for the year.

Average river depletions by Rincon and Mesilla Valleys

[Based upon diversions less drain return flow, 1930–46, in thousands of acre-feet]

Average diversions to Rincon and Mesilla Valleys (p. 72)	589.3 (gross)	447.9 (net)
Average drain flow returned to river (p. 72)	249.4	249.4
Average river depletions	339.9	198.5
Depletions, percent of average reservoir releases to project of 734,200 acre-feet, (omitting abnormal release for 1942), p. 39.	46	27

The water in the drains is composed of varying percentages of waste from the canals, seepage from canals, return seepage from irrigated lands, seepage from the Rio Grande, and flow of ground-water from the mesa lands to the valley.

Wastage from the canals to the drains supposedly is not included in the measured flow of the drains, the practice being not to measure the flow when it contains waste water, as indicated by a change in color of the drainage water. However, as this is not always practicable, it is probable that the measured flow of the drains contains some waste water.

RELATIONS OF DRAIN FLOW AND DIVERSIONS

A relation is to be expected between the ground-water recharge, represented mainly by return of irrigation water, and the ground-water discharge, represented mainly by drain flow. Knowledge of the relation is necessary in order to show the direct connection existing between the available surface supply and the return drain flow and to ascertain the amount of drain flow to be expected in a year of decreased surface supply.

As all components of the ground-water recharge to the valley fill, except that from the mesa lands and from precipitation, vary seasonally and annually with the amount of surface water available, it is logical to expect a seasonal and annual variation of the drain flow.

The relation of drain flow to reported net diversions has been plotted for the Rincon and the Mesilla Valleys in figures 2 and 3. On this type of graph the points should fall along a line if a relation exists between the variables, the line being straight if a linear relation exists. The points show some scattering but in general fall along the straight lines given, which indicate a drain flow of about 50 percent of the net diversions in the Rincon Valley and the Mesilla Valley, essentially the same as computed previously (p. 44).

The scattering of the points is probably mainly due to inaccurate estimates of canal wastes and therefore inaccurate figures for net diversions. Varying amounts of waste water inadvertently included with measured drain flow and varying amounts of seepage directly from the river to the drains also may be responsible in part for the scattering.

Also plotted on figures 2 and 3 are graphs of the drain flow and net diversions, by years, for the Rincon and the Mesilla Valleys. These graphs show, in different form, the same relations as those shown in the scatter diagrams, increases and decreases in net annual diversions generally being accompanied by increases and decreases in the drain flow.

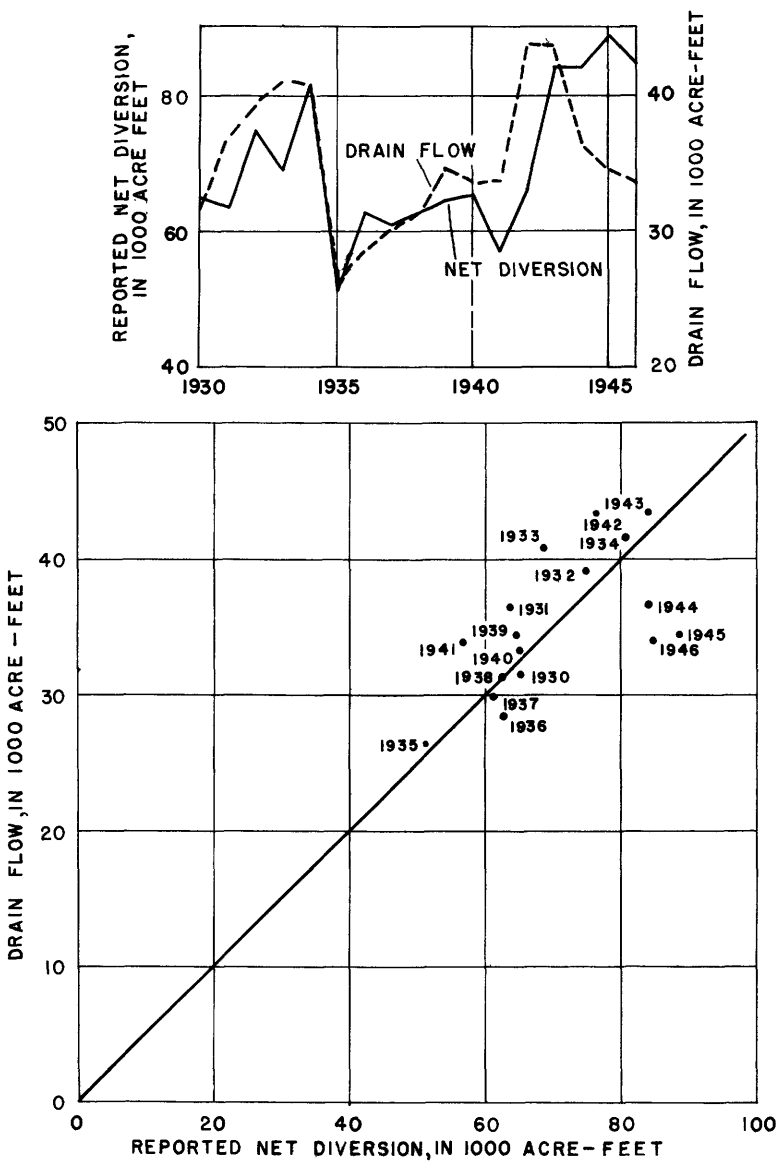

Figure 2. —Relation of reported net diversions to return drain flow in Rincon Valley, N. Mex.

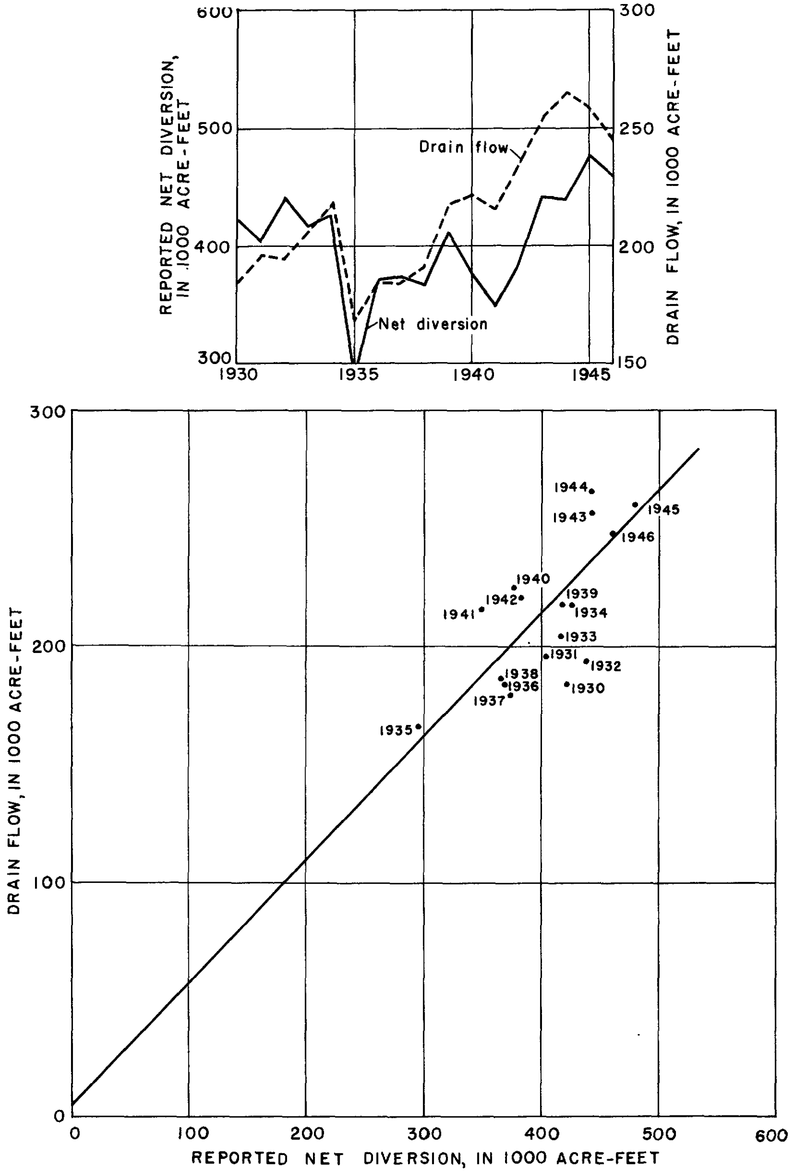

Figure 3. — Relation of reported net diversions to return drain flow in Mesilla Valley, N. Mex. and Tex.

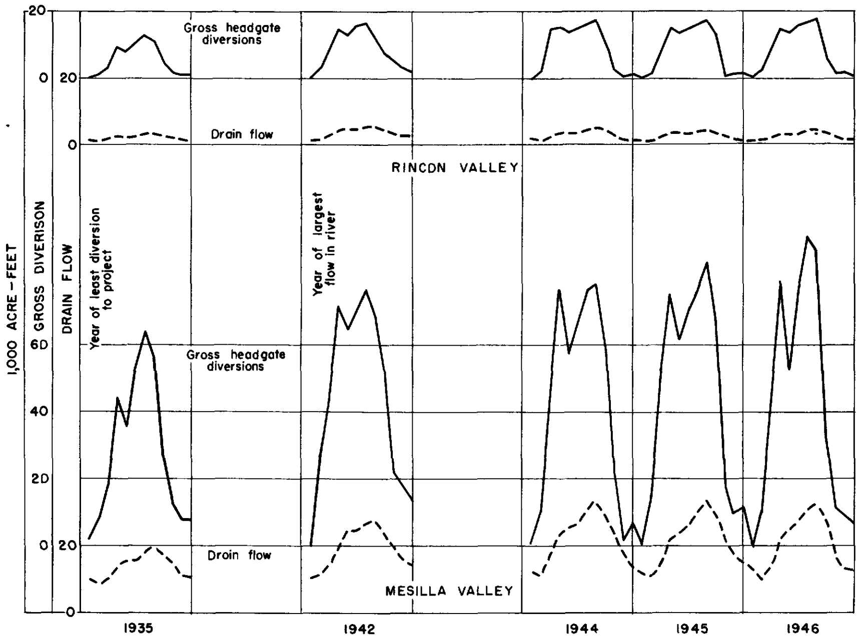

Figure 4. —Seasonal relations of gross headgate diversions and drain flow for selected years, Rincon and Mesilla Valleys.

In order to show the seasonal relations between diversions and drain flow, the gross diversions and the drain flow have been plotted by months on figure 4 for the Rincon and the Mesilla Valleys for the years 1935, 1942, and 1944-46. The smallest diversion to the project occurred in 1935; the largest flow in the river occurred in 1942.

The close relations between the diversions and the flow in the drainage ditches is readily apparent. The characteristic decrease in diversions each May is reflected in the drain flow, generally a month later, as either a slight reduction or a slackening in the rate of increase of drain flow. The maximum diversions occur in either July or August as, generally, does the maximum drain flow. As this flow would continue to decline as long as there were no diversions or water in the river, the time of minimum drain flow would not necessarily be related only to the time of minimum diversions. The minimum drain flow occurs in February just before the effects of the February diversions are apparent. Diversions in February are followed by increases in the drain flow by March. Evidently there is a very little lag in seasonal effects between the diversions and the return drain flow.

In order to determine whether a long-term lag effect exists, of the order of a year or more, between diversions and drain flow, figure 5 was prepared by plotting the cumulative annual departures

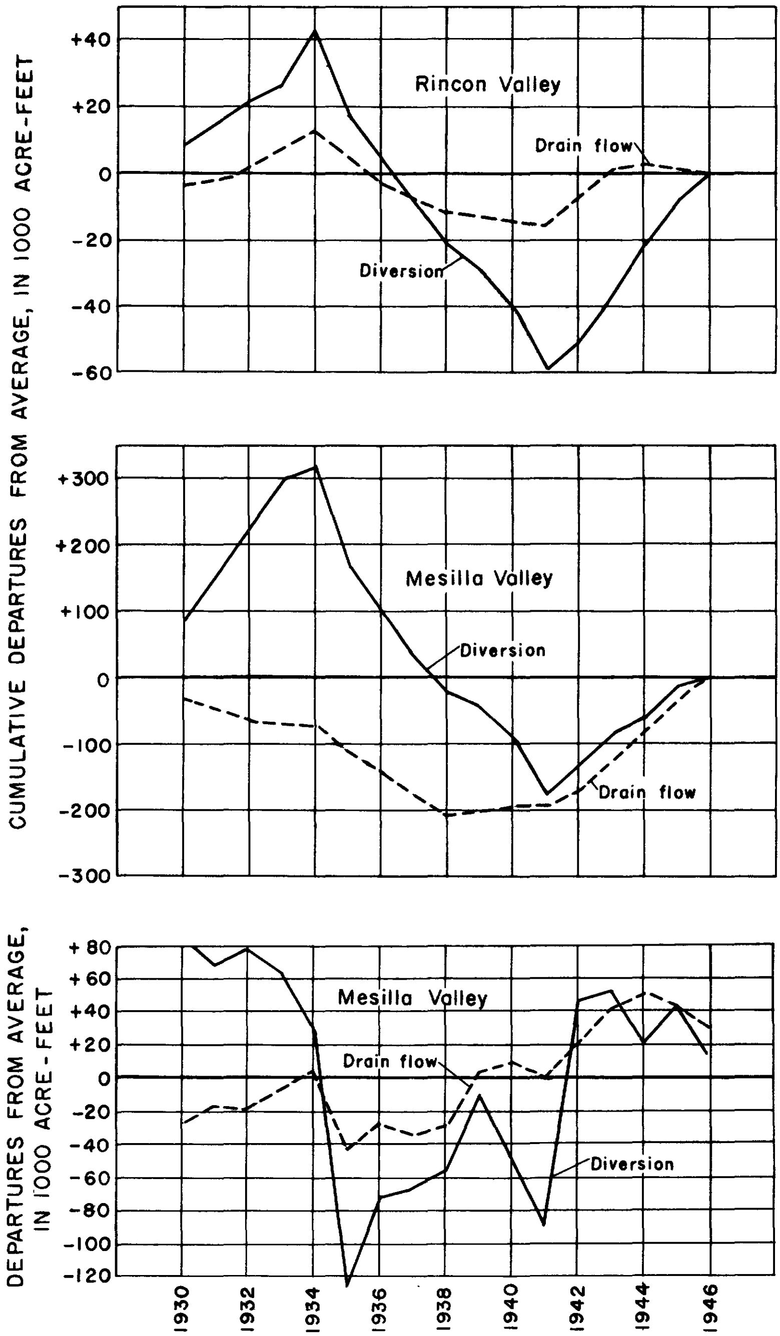

Figure 5. —Departures from average drain flow and diversions, Mesilla and Rincon Valleys, 1930–46.

from the average during the period 1930 to 1946 for both the return flow in the drains and the gross diversion in the Rincon and the Mesilla Valleys. Upward-trending lines indicate above-average conditions; horizontal lines, normal conditions; and downward-trending lines, below-average conditions. The graphs of drain flow and diversions for the Rincon Valley conform very closely except for 1945 and 1946, when an opposite trend between the two is indicated. No lag of the order of a year or more for the Rincon Valley is apparent.

The relation in the graphs for the Mesilla Valley is not so apparent. Below-average conditions of drain flow through 1938 are followed by above-average conditions. Diversions, on the other hand, show above-average conditions through 1934, followed by below-average conditions through 1941, after which above-average conditions again prevailed. It is possible that the above-average drain flow beginning in 1939 is related to the above-average diversions for a number of years preceding 1935, for which the beginning year is not known. If that is true, then the below-average diversions beginning in 1935 have not yet been reflected in the drain flow through 1946, a lag of at least 12 years. However, as the flow of the drains in the Mesilla Valley has shown a general increase from 1930 to 1944, the plot of cumulative departures does not show the relation that exists. Selection of a different figure for a base from which to compute departures from normal would result in a different graph.

The other graph, in figure 5, which shows only departures from average for the drain flow and the diversions for the Mesilla Valley, better portrays the relation and indicates little or no lag in the drain flow with an increase in the diversions, but possibly a lag of 1 or 2 years with a decrease in diversions.

REQUIRED WATER SUPPLY

In order to determine the amount of ground water that would be required for irrigation in a year with a shortage of surface water it is necessary to consider the quantity involved under the present conditions of irrigation with surface water exclusively.

During years of plentiful water supply the estimated average amount of water delivered to the lands of the project in the Rincon and Mesilla Valleys was 3.6 acre-feet per acre, 56 percent of that diverted. The minimum amount of water reported as delivered to the land from 1930 to 1946 was 1.74 acre-feet per acre for the Rincon Valley and 2.12 acre-feet per acre for the Mesilla Valley, amounts which are assumed to have been conservatively estimated as they represent only 23 and 29 percent, respectively, of the water available for delivery. The maximum percentage of diverted water that was delivered to the lands from 1930 to 1946 occurred in 1940 and amounted to 51 percent, or 2.78 acre-feet per acre, for the Rincon Valley and 58 percent, or 3.12 acre-feet per acre, for the Mesilla Valley.

The unit consumptive use for crops is subject to a large variation in both actual and computed use. The unit consumptive use of cotton in the Rincon and Mesilla Valleys for the 17-year period from 1919 to 1935 was estimated 2.5 acre-feet per acre in the report of the Rio Grande joint investigation, with minimum of about 2.0 feet and a maximum of about 3.0 feet. The unit consumptive use of alfalfa for the same period was estimated 4.5 acre-feet per acre, with range from 4 feet to 5 feet. The estimated consumptive use of other crops ranged from a minimum of 1.5 feet for grains to a maximum of 3.0 feet for forage, with an average of about 2.0 feet (National Resources Committee, 1938, v. 1, p. 382, 383). The acreage of cotton in the Rincon and Mesilla Valleys in 1945 was 66,624, of alfalfa 21,864, and of other crops 11,060 acres. The corresponding acreages in 1946 were 68,921 acres, 19,362 acres, and 12,628 acres. Using the unit figures given above, the total consumptive use of crops in 1945 was about 288,000 acre-feet and in 1946 about 285,000 acre-feet. The average unit consumptive use for the total irrigated acreage in the Rincon and Mesilla Valleys in 1945 was therefore about 2.9 acre-feet per acre and in 1946 about 2.8 acre-feet per acre. Precipitation probably furnished about 0.4 acre-foot per acre, leaving about 2.4 to 2.5 acre-feet per acre supplied by irrigation.

Assuming that in the period 1930 to 1946 the average consumptive use of water for the irrigated lands was the same as in 1945, 2.5 acre-feet per acre in addition to the amount furnished directly by precipitation, the excess water delivered to the lands was 1.1 feet, about 30 percent of that delivered to the farms of 17 percent of the gross annual diversions of 6.5 acre-feet per acre and 22 percent of the estimated net annual diversion of 4.9 acre-feet per acre. This return seepage of 1.1 acre-feet per acre from the irrigated lands plus that of 1.3 acre-feet per acre from the canals is about 37 percent of the gross or 49 percent of the estimated net diversion and is to be compared with the measured drain flow of 42 percent of the gross diversion.

The difference of 5 percent between the computed and measured percentages of the gross diversion represented by the drain flow probably is made up in part of waste water that has been included in the measured drain flow, seepage directly from the river, and ground-water flow from the side mesas to the drains.

The amount of water applied to the lands in past years doubtless was more than actually necessary, even though irrigation of crops requires that an excess of water be applied. It is therefore assumed that an excess of about 30 percent of the consumptive use of 2.5 feet, giving a total of 3.3 feet of irrigation water, would be sufficient to grow a normal crop in the Rincon and Mesilla Valleys.

In a dry year with a shortage of surface water, canal waste could be reduced by careful attention to water schedules. The minimum reported percentage of canal wastage occurred in 1946 for each division and ranged from 8 percent in the Leasburg division to 14 percent in the Rincon Valley. It seems reasonable, therefore, to assume that wastage could be reduced to 5 percent. This would be likely if a project pumping system were operated, in which case cancellation of water orders by the farmers could be handled quickly by stopping the necessary pumps. Of course, the canal waste water is not actually wasted, except that lost by evaporation, if used for irrigation of lands in a lower part of the valley. However, excessive wastage makes it necessary for the lower operating units to change their diversion schedule or in turn to waste the water.

Also, in a dry year the canal-seepage losses probably would be relatively higher than the 20 percent in an average year, probably about 25 percent of the gross diversion. The delivery of water to the lands would therefore be about 70 percent of the surface-water diversion.

In a hypothetical year having 3.25 acre-feet per acre or 50 percent of an average supply of surface water available for diversion, 70 percent or 2.28 feet of water could be delivered to the farms, or about 70 percent of the 3.3 feet believed necessary to raise a normal crop. Thus, in a year when the available surface supply was only 50 percent of the average, about 70 percent of the land probably could be irrigated with judicious use of water without pumping; or, as about two-thirds of the total acreage is planted to cotton, the main staple crop of the district, sufficient water would be available to water the entire cotton crop. This would be possible if every care in the distribution of the water were exerted by the farmers and ditch riders.

GROUND WATER IN VALLEY FILL

DEPTH TO WATER

The depth to water in the Rincon and Mesilla Valleys in the early years prior to construction of Elephant Butte Dam was considerably greater than at present. The flow of the Rio Grande at that time was unregulated and there were periods when there was no flow of water. The amount of water applied to the lands was quite variable, large amounts being applied when available and none during periods when the river was dry. The amount of land irrigated in early years was relatively small, about 26,229 acres in the Mesilla Valley and 4,370 acres in the Rincon Valley in 1907 (National Resources Committee, 1938, p. 75).

By 1914 the irrigated acreage had increased to about 45,356 acres in the Mesilla Valley and 6,961 acres in the Rincon Valley (National Resources Committee, 1938, p. 75). The increase resulted partly from construction of the Leasburg diversion dam in 1908 by the Bureau of Reclamation and partly from improvements in the distribution system. As a result of the increase in irrigated acreage, the water table rose.

The first water from the Elephant Butte Reservoir was made available to the project in 1915. The reservoir not only assured a more plentiful supply of water but also resulted in clear water being available, whereas formerly silt-laden water had been used. The clear water seeped more rapidly from the canals, and, as the clear water also drained faster from the irrigated lands, more water was applied to the lands. These conditions, described in the project histories of the Bureau of Reclamation, resulted in a rise of water level to alarming heights and caused abandonment of productive farmlands.

The change in water level is shown by the profiles of the water table in the vicinity of the State Agricultural College and westward to the river on plate 4, which has been taken from a similar diagram prepared by the Bureau of Reclamation in 1927. The low water table shown in 1904 was taken from Slichter (1905, p. 26-27). The water level given for June 1917 ranged from nearly 6 feet to as much as 12 feet above the level of 1904 and in some low spots was at the surface. Four years after construction of the drains the water table had been lowered 1 to 4 feet in the areas between the drains in the vicinity of the cross section, to the level given for June 1927.

The rise of the water table from 1904 to 1916 in the vicinity of Mesilla Park, in the locality of the cross section, is given in the following table obtained from the Bureau of Reclamation[7].

[7]Fiock, L. R., 1917, Drainage report, Rio Grande project, U. S. Bur. Reclamation unpublished report. El Paso, Tex., February 1917.

Rise of water table in vicinity of Mesilla Park, N. Mex., 1904–16

Year	Average depth to water (feet)	Rise of water table	
		Period (feet)	Per year (feet)
1904	11.5		
1915	7.0	4.5	0.4
1916	5.7	1.3	1.3

The rise of the water table to within 4 feet of the ground surface in 33,000 acres, representing 40 percent of the irrigable area south of T. 23 S., resulted in a reduction of irrigated land to 47,000 acres by November 1916[8].

As a result of the high water table in the Mesilla Valley, plans were made for the installation of open drains. In order to determine the depth to water and the configuration of the water table, preparatory to construction of the drains, the Bureau of Reclamation in the period 1913 to 1917 bored about 800 holes with hand augers in the Mesilla Valley. These holes were located on the east-west section lines across the valley at intervals of about a quarter of a mile, except on the east side of the river from a mile north of Berino to 2 miles south of Fort Fillmore, where additional holes were put in at quarter-mile intervals on east-west lines midway between the section lines. Plate 5 is a water-table map prepared by the Bureau of Reclamation in 1917 from measurements made in these holes in June 1917. The areas having various depths to water are indicated by shading. About 4 percent of the reported area had water standing on the surface, and more than 66 percent of the area had water within 4 feet of the surface. The sloughs and meanders of the old river beds are clearly shown by the pattern of the depth to water, particularly that of the water on the surface and ground water within 2 feet of the surface. At that time (1917) about 6 miles of the east drainage ditch had been completed. The effect of the lowering of the water table in the vicinity of the east drain is clearly shown.

The depth to water in the auger holes in the summer of 1919 is shown on the map prepared in September 1919 by the U. S. Bureau of Reclamation. (See pl. 6.) The drains that had been constructed by that time are indicated on the map. The lowering of water level that occurred in the vicinity of the completed drains is apparent. The following table from the Bureau of Reclamation report[9] shows the change in water levels that occurred in two districts from June

[8] Fiock, L. R., op. cit.
[9] Fiock, L. R., 1920, Rio Grande project history, 1919: Ch. 9, U. S. Bur. Reclamation, El Paso, Tex., January 1920.

Comparison of depth to water in Mesilla Valley in drained part of the west side unit in September 1919 with corresponding conditions in June 1917 before draining

[Note: Drainage construction was progressing through the above districts in September 1919]

Depth to water (feet below land surface)	La Union district				Upper west side district			
	1917, before construction of drains		1919, area affected by drains		1917, before construction of drains		1919, area affected by drains	
	(acres)	(percent)	(acres)	(percent)	(acres)	(percent)	(acres)	(percent)
On surface	175	1.0	6	0.04	1,748	8.5	63	0.67
0 to 2	3,118	17.1	278	1.95	5,224	25.6	229	2.44
2 to 4	11,027	61.4	628	4.4	8,171	39.8	867	9.23
4 to 6	[1]3,665	20.5	4,230	29.6	[1]5,376	26.2	2,149	22.85
6 to 8	...	...	5,799	40.6	...	...	3,570	38.0
Over 8	...	...	3,339	23.4	...	...	2,521	26.81
Total gross area	17,985	100	14,280	100	20,519	100	9,399	100
Area affected by drains	0	0	14,280	79.4	0	0	9,399	45.7
Total area in which water is less than 4 feet	14,320	79.5	912	6.39	15,143	73.9	[2]1,159	12.34
Total area in which water is 6+ feet	([3])	([3])	9,138	64.01	([3])	([3])	6,091	64.81

[1]Includes everything over 4 feet, practically all between 4 and 6 feet.
[2]Practically all in old riverbeds.
[3]Practically none.

1917 to September 1919. In the La Union district, where 79 percent of the area had water at less than 4 feet in June 1917, only 6 percent of the drained area had water at less than 4 feet in September 1919. Similar conditions are shown for the upper west side district.

Additional overall lowering of the water level has occurred since September 1919. At that time only a part of the drainage system had been completed, and sufficient time had not elapsed for the water level to become stabilized. On the profile in plate 4 has been plotted the water level in September 1919 as scaled from the water-table contours on the map, plate 6. At that time the Mesilla drainage ditch had been completed to a point a little less than a mile north of the line of the profile. As shown, the water level in the Mesilla Drain in September 1919 was practically the same as in June 1927, whereas water levels at some distance from the drain were higher in September 1919 than in June 1927. With two additional drains across the line of the profile and the 8 years of additional drainage, the water levels were lowered about 3 feet in areas between the drains.

A comparison of depths to water in a few of the auger holes, as measured in late August 1946 by the Bureau of Reclamation, with the depths to water as taken from the map for September 1919 are given in the following table. The designations of the wells are as shown on plate 3.

Changes in depth to water in Mesilla Valley, N. Mex., as measured in auger holes in late August 1946 and as determined from depth-to-water map of September 1919

Hole designation	Depth to water (feet)		Change (feet)	Hole designation	Depth to water (feet)		Change (feet)
	September 1919	August 1946			September 1919[1]	August 1946	
5	1.8	4.4	-2.6	32	6.0	6.2	-0.2
6	2.0	3.4	-1.4	33	5.7	5.0	+.7
9	2.5	5.6	-3.1	Dunn	8.2	6.5	+1.7
15	4.2	8.3	-4.1	Bartlett	8.5	7.9	+.6
16	6.0	8.0	-2.0	Liberty	7.8	5.4	+2.4
17	6.0	4.6	+1.4	Thalman	8.0	6.7	+1.3
23	4.0	9.8	-5.8	Bloomberg	5.8	5.8	0
27	2.5	6.6	-4.1	Berino	5.0	4.4	+.6
37	4.2	3.5	+.7	Rice road	6.5	5.1	+1.4
40	3.8	5.9	-2.1	Opitz	3.3	2.4	+.9
46	4.1	7.6	-3.5	Pool	7.0	5.4	+1.6
Stahman	2.0	7.6	-5.6	Campbell	4.0	2.8	+1.2
Duran	4.5	9.3	-4.8	McKamey	3.9	3.3	+.6
Mesquite	4.5	4.7	-.2	Dairy farm	7.0	7.8	-.8
Sweet	3.8	4.0	-.2	HighSchool	8.0	4.6	+3.4
Find	3.7	2.6	+1.1	Anthony West	5.3	4.1	+1.2
Vado	3.9	4.2	-.3	Longwell	6.0	2.0	+4.0
Anthony head	5.0	4.4	+.6	Borderland	5.3	4.9	+.4
Three Saints	3.8	4.7	-.9	Wade	7.8	4.0	+3.8
La Union	3.0	6.2	-3.2				
Average			-2.0	Average			+1.2

[1]Affected significantly by drainage by 1919.

Only parts of the Mesilla Valley, particularly the lower half, had been affected by drainage by September 1919. Wells located in such areas are indicated in the table. The depth-to-water measurements given in the table are not as accurate as desired. The land surface near a well tends to change position, especially as there has been considerable leveling of the land since 1919. The depths to water taken from the map are subject to errors of as much as 2 feet; an error in location of a well, for instance, such as occurs in an area of rolling topography, may affect the determined depth to water by that amount. The map itself is subject to error at any particular spot. The time of observation for the 2 years differs possibly by a month, which in itself may account for a difference of water level. With these factors in mind, it seems that tne water table in areas not yet affected by drainage in September 1919 had declined by late August 1946 from 2 to 6 feet, with a probable average of more than 2 feet, whereas the water table in areas affected by drainage in September 1919 was higher in late August 1946 possibly by as much as a foot. This rise may be partly due to a clogging of the drains or a decrease in the depth of the drains by filling with debris and, also, partly to the increase of irrigated land since 1919.

About 220 holes were bored with hand augers in 1917 and 1918 in the Rincon Valley. Maps of the water table from a mile north of the Sierra County line to R. 2 W. were prepared by the U. S. Bureau of Reclamation from the measurements made in these wells, probably in 1919 prior to construction of the Garfield and Hatch Drains. The accompanying map, plate 7, was taken from the original maps which were drawn to a scale of 500 feet to an inch. The water table at that time ranged from land surface to more than 4 feet below land surface and was from 2 to 4 feet below land surface in a large part of the area. The lowering of water level that has taken place since construction of the drainage system is not known, although it is probably similar to that which occurred in the Mesilla Valley.

The changes in water level in the Rincon Valley are given in the following table. The measurements for 6 of the wells are for August when the water table normally is near or at its seasonal high, and those for the other 3 wells are winter readings when the water table is near its seasonal low level. As the time of the water levels shown on the maps prepared in 1919 is not known, and as the seasonal range of water levels is about 4 feet, the changes shown in the table are not conclusive as to amount but indicate a probable drop of more than 2 feet from 1919 to 1947.

The water level in the Rincon Valley, in the area near the lower end of the Rincon Drain in 1926 after completion of the drain, is also shown on plate 7. In about half the area the depth to water was in excess of 4 feet.

Changes in water level in Rincon Valley, N. Mex., as measured in wells in August 1947 and as determined from depth-to-water map of 1919

Well location number	Occupant of property	Depth to water (feet)		Change (feet)
		1919	August 1947	
17.4.32.112	Painter	2	6.6	-4.6
17.4.31.111	Luchini	4	5.5	-1.5
18.4.5.214	Prater	6	[1]13.4	-7.4
18.4.17.312	Engler	4	5.3	-1.3
18.4.17.411	Riggs	3	[2]8.3	-5.3
19.3.10.333	Cocks	5	5.0	0
19.3.10.432	Stotts	6	9.1	-3.1
19.3.9.121	Hatch	2	3.4	-1.4
19.3.15.443	Smallwood	1	[3]5.6	-4.6
Average				-3.2

[1]February 1948.
[2]December 1947.
[3]February 1947.

FLUCTUATIONS OF THE WATER TABLE

Changes in water level in the Mesilla and Rincon Valleys are brought about by return of irrigation water, canal and river seepage losses, precipitation, transpiration and evaporation, and, in part, by changes in the level of the drains and the river. Daily, weekly, seasonal, and yearly changes in the water level are the net effect of all these factors.

EFFECT OF IRRIGATION

The lands are irrigated during the summer months, with about 83 percent of the diversions from the Rio Grande occurring from April through September. Return seepage from irrigation and seepage from canals and the river all occur about the same time; the result is that water levels in the valleys and along the edges of the adjoining mesas are higher in late summer than in late winter. Figure 6 shows the fluctuations of water level as measured daily at 5 p. m. in an auger hole, 23.2E.29.214, on the east edge of the valley in the northeast corner of a field at the weather-instruments shelter of the Agricultural College. The field is a grass-covered athletic practice field that is irrigated about once a month. The times of irrigation, as noted by the local observer, are plotted at appropriate points on the graph. A major "peak" in the water level occurred about 1 day after each irrigation of the surrounding field. Weekly fluctuations are roughly indicated, and

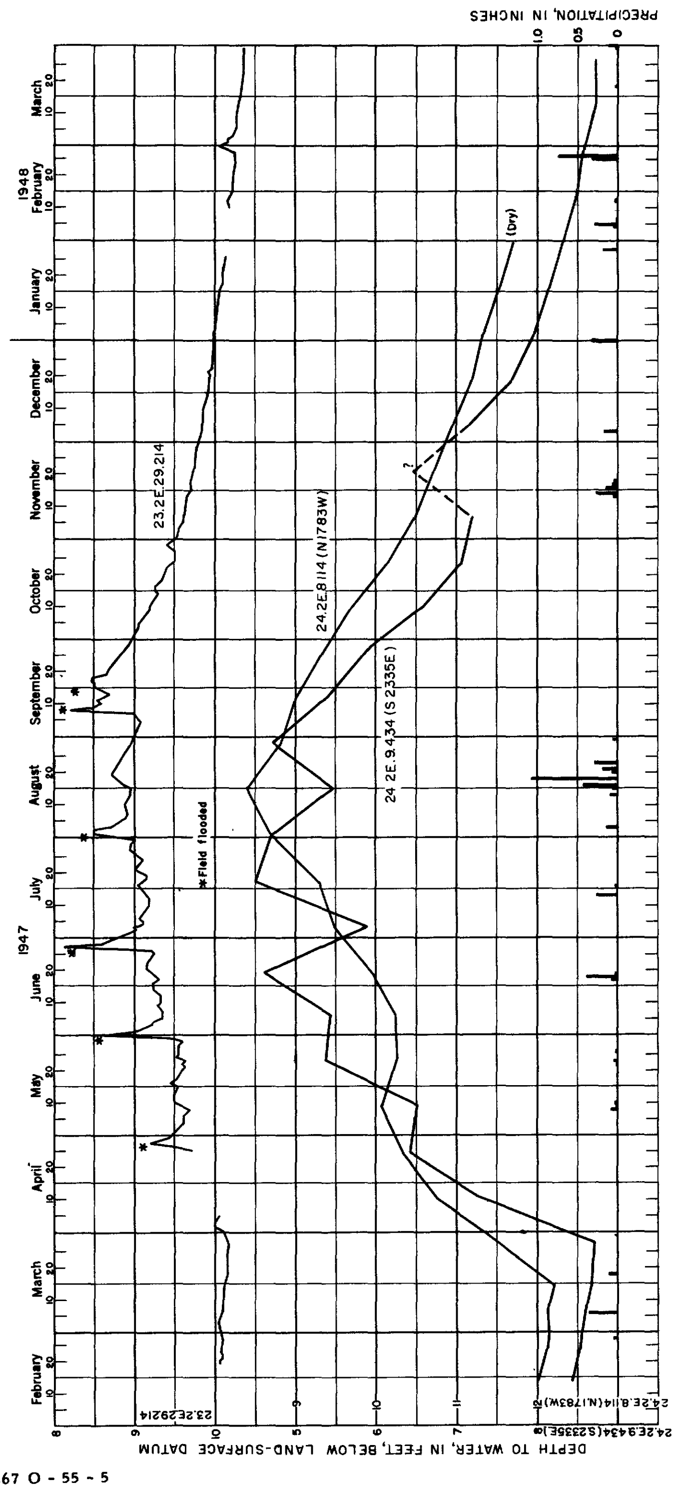

Figure 6. —Fluctuations of water level in three auger holes in Mesilla Valley, and precipitation at State College, N. Mex.

probably correspond to the times of irrigation of nearby lands. The low level was reached in late March and the high level—except for a short-lived peak in June—in early September. A nearly continuous rise occurred from March to September while water was being diverted to the canals.

Also plotted on figure 6 are graphs of water levels from measurements made every 2 weeks in 2 other auger holes. Well 24. 2E. 9. 434 is 2, 335 feet east of the Park Drain along the Seale road. Well 24. 2E. 8. 114 is 1, 783 feet west of the Park Drain along the Holt road, which is about a mile north of the Seale road. Irrigated fields are on both sides of the 2 roads.

The graphs for these two auger holes show marked summer highs like the preceding auger hole but differ from each other in their minor fluctuations. The smaller rises in water level in May than in April reflect the characteristic decrease in diversions to the valleys in May, which is also reflected in a decrease in drain flow, as indicated previously. The magnitude of the seasonal change in water level is dependent upon the location with respect to nearby drains, canals, and irrigated lands.

The Bureau of Reclamation has measured water levels at monthly intervals for a number of years in about 50 auger holes distributed over the Mesilla Valley, from about 7 miles south of Leasburg Dam to the southern edge of the valley. About 15 of these wells are so-called sample wells that were bored in 1936 for the purpose of obtaining samples of ground water for chemical analysis during the time of the Rio Grande joint investigation. The remaining holes were bored in 1924. The water levels have been measured roughly to the tenth of a foot by a "sounder" attached to the end of a metallic tape. The available records of water level in 11 of the auger holes are plotted in plate 8. In addition to the well location number, the number or name of the hole as designated by the Bureau of Reclamation is given; the holes are located on plate 3. Sample wells on plate 8 are designated by a number, enclosed in parentheses following the hole number or name, which corresponds to the number assigned during the Rio Grande joint investigation.

The water level in each auger hole indicates the yearly cycle, the high level occurring in late summer in response to return of water diverted from the canals, and the low level occurring in the late winter. The reduction in diversions that usually occurs in May of each year is generally reflected by a lowering of the water levels in the auger holes. However, as the time of measurement of the water levels has varied each month, this lowering of water level is not always apparent. The detailed and long-term trend in water levels shown in each well is a net result of factors surrounding each well, such as a change in the amount of water applied to nearby lands, which in turn can be caused either by a change in type of crops grown or by a change of irrigation practices. As the valley is traversed by drains, the minimum level of the ground-water table at any point is controlled largely by the elevation of the bottom of nearby drains. As a drain gradually fills with debris over a period of years, the nearby water levels will rise until such time as the drain is cleaned. In the early years of the project a smaller proportion of the land was irrigated than in late years. Irrigation of new land near an auger hole causes a gradual rise in water level in that hole over a period of time until approximate equilibrium is again reached. None of the above factors is known concerning the area around a particular well.

The auger holes for which records through 1946 are available are shown on plate 3. Wells 32, 33, and 37 are on an east-west line east of Mesilla Dam, and their water levels are plotted on plate 8 to show that water levels in the same general area are affected differently. The graphs show a general agreement but differ in detail. Well 37 shows a greater seasonal change than wells 32 or 33, which may be partly due to seepage from the east side canal in the vicinity of well 37. There was a lowering of the water level in 1935 in all the wells coincident with reduced diversion in that year, and a rise of water level in 1942 coincident with the increased diversion and river flow in that year. Minor fluctuations shown on the graph may be in part due to inaccuracies in measurement of the water levels.

If a true average water level could be obtained over the Mesilla Valley, it is probable that the average yearly levels would fluctuate with the annual diversion and the long-term trend in levels might show a slight rise because of increased irrigated acreage; this might be offset in some areas by a lowering of water levels resulting from the lowering of the riverbed by scouring.

Water levels were measured at about monthly intervals during 1947 in approximately 18 wells, mostly irrigation wells, in the Rincon and Mesilla Valleys in order to observe the change in level throughout the year. A few of the observation wells are located in sedimentary deposits above the level of the alluvium in the valleys. Fluctuations of water level in 7 such wells are shown in figure 7.

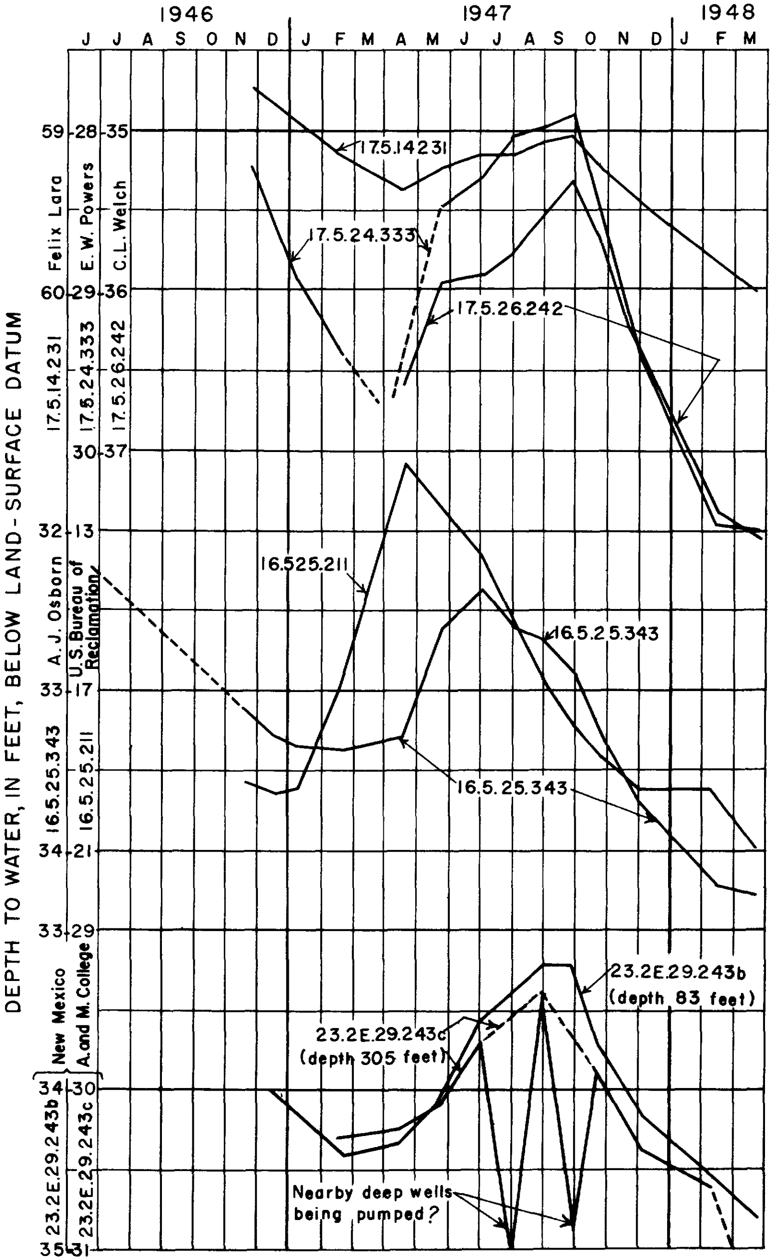

Figure 7. —Fluctuations of water level in seven wells located in arroyo beds or in sediments above the valley floor of the Rio Grande.

Well 17.5.14.231 belonging to Felix Lara, is an unused well near the northern end of the Rincon Valley on the south side of Montoya Arroyo, about 0.8 mile west of the Arrey Canal which at this point follows the western edge of the valley floor. The water level in this well is about 10 feet above the water level in the river which is about 1 1/4 miles to the east. Wells 17.5.24.233 and 17.5.26.242, belonging to E. W. Powers and C. L. Welch, are wells used for irrigation near the northern end of the Rincon Valley in Tierra Blanca Creek, above the valley floor and about 1,500 feet west of an irrigation lateral. The water level in these three wells reached the low level for the year in April and the high level near the end of September. A slight reduction in the rate of rise of the water level in June or July seems related to the decrease in diversions in the valley in May. The trend of the water levels in these wells during the year is the same as that in the auger holes on the floor of the Mesilla Valley and shows the relation of the ground water under the adjoining mesas to that in the valleys.

The fluctuations of the water level in 2 unused wells at the State Agricultural College in Mesilla Valley are also given in figure 7. The ground surface at these wells, 23.2E.29.243b and 23.2E.29.243b (83 and 305 feet deep, respectively), is from 15 to 20 feet above the level of the valley. The times of the seasonal high and low water levels in these wells correspond to those in wells in the valley, and again indicate a close relation between the water in the valley and that under the adjoining higher lands. The altitude of the static water level in February 1947 was nearly the same in these 2 unused wells, from 0.5 to 1.0 foot below the water level in the valley. Two domestic wells, 228 and 428 feet deep, are about 100 feet from the 2 unused wells. The water level in the 305-foot unused well seems to be influenced by pumping in the deep domestic wells. The upper water in the 305 foot unused well is cased off, only water near the bottom entering the well.

Wells 16.5.25.211 owned by the U. S. Government (Bureau of Reclamation) and 16.5.25.343 belonging to A. J. Osborn, are south of Caballo Dam and on ground above the level of the valley floor. Well 16.5.25.211 is on the north side of the former channel of Percha Creek, about 1,000 feet south of the dam, and well 16.5 25.343 is on the south side of the former channel of Percha Creek on a line perpendicular to the dam through well 16.5.25.211 and about 5,800 feet south of the dam. Fluctuations in the water level in these two wells, shown in figure 7, seem related to the seepage from Caballo Reservoir, which varies with the reservoir level. The high level in the reservoir occurs each year in mid-March and the low level in mid-September.

EFFECT OF PRECIPITATION

Precipitation in the Rincon and Mesilla Valleys causes changes in the water levels. The water table rises as the ground water is recharged from precipitation percolating downward and as a result of reduced transpiration by plants that normally get their water from the ground-water body. However, at times of precipitation, application of irrigation water to the lands is usually reduced or stopped. The effect of the reduced recharge from irrigation water probably more than offsets the effect of the slight recharge from light precipitation, and thus a lowering of the water level results. Precipitation in the Rincon and Mesilla Valleys is small, amounting to only 6.08 inches in 1947 at State College (2.60 inches below normal) and 4.88 inches at Caballo Dam. The effect of precipitation on the water level is expected to be small except during moderate to heavy showers, when the precipitation that reaches the water table may offset the decrease in recharge from irrigation water. The moisture content of the soil at the time of precipitation influences the amount of precipitation that reaches the water table, showers on wet soil having a greater effect than those on dry soil. As the soil generally contains more moisture in the summer than in the winter because of irrigation and as more than half of the total annual precipitation occurs in July, August, and September, probably most of the recharge to the ground water from precipitation in the valley comes from showers in the summer.

The daily precipitation at State College in 1947 and part of 1948 has been plotted on figure 6 along with the water levels measured daily, about 5 p. m. in the auger hole, 23.2E.29.214, located beside the rain gage. Some showers during the summer caused rises in the water level, whereas others apparently had little effect or were accompanied by slightly lower levels resulting from reduced irrigation. Precipitation from August 20 to 23 totaled 0.52 inch and apparently did not affect the water table, whereas that from June 17 to 19, of 0.49 inch, caused a rise of 0.16 foot in the water level in the auger hole. The heavy rains from August 13 to 18 totaled 1.65 inches, of which 1.06 inches fell on the 18th, and apparently caused a rise in the water level of 0.23 foot. Comparatively heavy rains in the winter seemingly had little or no effect on the water level. Precipitation from November 13 to 18 of 0.60 inch caused only a slight temporary decrease in the rate of lowering of the water table. Heavy rains February 27 and 28, 1948, amounting to 1.05 inches, caused an apparent rise of water level of 0.21 foot.

EFFECT OF TRANSPIRATION

In areas of native vegetation where the water table is shallow, the water level shows a typical diurnal fluctuation, falling during the day and rising during the night. The fluctuation is small, generally less than two-tenths of a foot in most areas where such fluctuations have been investigated. The fall of the water level in the daytime is caused by the use of water by plants, producing an effect similar to a small pump. After sundown the transpiration from the plants becomes small or ceases and the water levels recover.

Fluctuations of water level in nine wells in the middle Rio Grande valley near Socorro, N. Mex., in groves of cottonwood, tornillo, and willow, and in saltgrass meadows, are given in the report of the Rio Grande joint investigation (Theis, 1938, p. 275-276). Records of fluctuations of water level due to transpiration in the Rincon and Mesilla Valleys were not obtained but are believed to be similar to those in the middle Rio Grande valley.

SOURCE AND MOVEMENT OF GROUND WATER

Ground water is seldom stationary but nearly always moving from an area of recharge to an area of discharge. The direction of flow of the ground water gives an indication of the sources of recharge and areas of discharge. Because ground water flows down gradient, just as surface water does, altitudes of the water table determined at many places will show the direction of flow of the ground water, which is at right angles to the contours of the water table. A change of gradient of the water table is shown by a change in spacing of the contours, and under natural conditions it indicates a change in velocity of the ground water brought about by a change in the amount of water flowing through the sediments under consideration, a change in the thickness or width of the formation, a change in the permeability of the aquifer, or a combination of changes in any of them.

DIRECTION OF MOVEMENT

The direction of movement of the ground water under the valley floor of the Rincon and Mesilla Valleys is indicated by the contours of the water table shown in plates 5-7. The general direction of flow is down the valleys. Superimposed on this general circulation of ground water are circulations of smaller scale such as, lateral flow into the drains—in places, more or less directly from adjacent canals or the river—flow from the bordering uplands, and, in places, flow from or to the river. Plate 9, taken from a map prepared by the Bureau of Reclamation, shows a direct flow from the Three Saints lateral eastward to the Anthony Drain. Figures 9 and 10 show direct flow in the vicinity of Hill from the Leasburg Canal to the Leasburg Drain.

In the Mesilla Valley in June 1917, the average gradient of the water table along the axis of the valley from the 3,900-foot contour near the north end of the valley to the 3,710-foot contour near Montoya, a distance of about 42 miles, was about 4.5 feet to the mile, the same as that of the ground surface. The gradient at any particular spot as determined from the spacing between 10-foot contours on the map of the water table for June 1917 ranged from as little as 3 feet to the mile, just north of Chamberino, to as much as 10 feet to the mile, just north of Las Cruces. The gradient of the water table as determined in September 1904 from a line of wells from Las Cruces to a point south of Mesilla, a distance of nearly 5 miles, was 4.64 feet to the mile (Slichter, 1905, p. 24, 25).

It is believed that the average gradient of the water table down the valley at the present time is essentially the same as in 1917, the effect of the drains having been an overall lowering of the water table.

The gradient of the water table in 1919 in the Rincon Valley from the 4,070-foot contour 1 mile north of the Dona Ana County line to the 3,994-foot contour, a distance of about 16 miles, was about 4.8 feet to the mile, essentially the same as that of the ground surface. (See pl. 7.)

SOURCE OF GROUND WATER

The ground water in the valley fill is derived from a number of sources, the quantity from each being generally indistinguishable. Water is derived from seepage from the river in various sections, seepage from the canals and laterals, seepage from irrigation water applied to the lands, ground-water flow from the bordering mesa lands, precipitation upon the valley floor and adjacent mesas, and a small amount from flash floods in the arroyos that discharge from the mesas to the valley.

SEEPAGE FROM THE RIO GRANDE

In several stretches the river loses water to the ground-water body, as indicated by the contours on the water table in the accompanying maps. Seepage from the river in the Mesilla Valley in

June 1917 is indicated at the Mesilla diversion dam between the 3,830- and 3,820-foot contours. (See pl. 5.) The seepage from this stretch may be due partly to raising of the river level by the diversion dam. A pronounced seepage loss from both sides of the river is indicated from Fort Fillmore to Mesquite between the 3,810- and the 3,790-foot contours. Seepage from the river is also indicated in the vicinity of Montoya from the 3,712-foot contour to below the 3,704-foot contour. Other isolated contours show seepage loss from the river. In some stretches, such as from opposite Chamberino to opposite Anthony between the 3,758-foot contour and the 3,740-foot contour, the river is shown to be gaining water. It is shown to be gaining water on the north side of the bend opposite Dona Ana and probably losing water from the south side. In June 1917, before construction of the drains, the river apparently was losing more water than it was gaining. This condition probably was responsible in part for the high water table.

In September 1919, after construction of a number of the drains, the seepage loss from the river apparently increased, as evidenced by the steep water-table gradients from the river to the drains. (See pl. 6.) Increased seepage losses are especially apparent in areas where the drains, such as the Chamberino Drain, were constructed near the river. This seepage loss from the river induced by the drains does not mean an actual loss of water from the valley, as the drain water is discharged into the river farther down the valley.

The seepage loss from the river has been changed somewhat by the storage of water in Elephant Butte Reservoir. Previous to this storage, the river water that was used in the Rincon and Mesilla Valleys contained the usual load of silt, which during normal flows sealed the riverbed and canals to some extent. After release of clear reservoir water began in 1915, a greater amount of seepage occurred from the river and canals. This increased seepage loss was in part responsible for the rapid rise in ground-water levels that necessitated construction of the drains.

The clear water also has had a tendency to scour the riverbed. The scouring has been helped by the program of river rectification of the International Boundary and Water Commission, which has consisted of confining the river in a narrow channel and straightening or cutting off large bends of the riverbed. From 1917 to 1932 the river from Percha Dam to Leasburg Dam was shortened about 2.93 miles and from Leasburg Dam to International Dam was shortened about 2.81 miles.[10]

[10] U. S. Army Corps of Engineers, Albuquerque district, 1947, Survey for flood control, Rio Grande and tributaries: v. 8, appendix F, Sedimentation, chart 87, Sept. 1, 1947.

The average annual degradation of the riverbed from 1917 to 1932, from 1932 to 1941, and from 1941 to 1942 is given in the following table. The values were obtained by the U. S. Army Corps of Engineers by taking the average of the lowering at 1-mile intervals from profiles of the riverbed as prepared by the International Boundary and Water Commission. The profile in 1917 was of the water surface while, 2,000 cfs was being released from Elephant Butte Reservoir. The riverbed was assumed to be 1.5 feet below the water surface. The profiles of the riverbed for both 1941 and 1942 were taken in December of each year, before and after the large spill (maximum of 8,000 cfs) from Elephant Butte Reservoir in early 1942. This large spill caused considerable scouring, as shown in the table. Complete data for the Rincon Valley for years succeeding 1932 are not available. Six cross sections of the river in the Rincon Valley, obtained from the International Boundary and Water Commission, indicate a lowering of the riverbed from 1932 to 1943 from near Hatch southward. However, the cross sections are too few to show the conditions for all the valley. Reports of a few farmers indicate scouring in sections of the Rincon Valley comparable to that in the Mesilla Valley. Some lands bordering the river in the upper portion of the valley that formerly could be farmed without irrigation, because the water table was accessible to plant roots (the practice being called subirrigation), have not been suitable for farming in that way in the last few years because of the lowered water table.

Degradation of the bed of the Rio Grande, Percha Dam to Courchesne bridge, 1917–42

[U. S. Army, Corps of Engineers, Albuquerque district, N. Mex., Sept. 1, 1947, Survey for flood control, Rio Grande and tributaries: v. 8, appendix F, Sedimentation, chart 87]

Section	Average annual degradation in feet			Total 1917-1942
	1917-1932	1932-1941	1941-1942	
Percha Dam to Leasburg Dam	0.14	....	....	[1]2.08
Leasburg Dam to Mesilla Dam	.11	0.07	0.95	3.28
Mesilla Dam to Courchesne bridge	.07	.10	.40	2.36

[1]1917-1932.

The table shows an average degradation of the river bed of more than 2 feet in the Rincon and Mesilla Valleys from 1917 to 1942. However, greater scouring has taken place in the upper part of each valley. In the Rincon Valley practically all scouring from 1917 to 1932 was north of the Haynor bridge, about 10 miles south of Hatch, where a maximum scouring of 7 feet was measured in 2 sections. In the section from Leasburg Dam to Mesilla Dam all the scouring took place above a point about 5 miles north of the Mesilla Dam, a maximum of 8.0 feet from 1917 to 1942 occurring in the section 3 miles below Leasburg Dam. In the section from Mesilla Dam to Courchesne bridge, all the scouring from 1917 to 1942 took place above Montoya, about 8 miles north of Courchesne bridge, a maximum of about 5 feet occurring about 9 miles below Mesilla Dam.

The probable effect of this degradation of the riverbed has been to reduce the seepage loss from the river. However, the installation of drains in the valleys has tended to increase the seepage loss from the river, which may have offset the decrease due to the degradation of the river bed.

Very few seepage runs have been made on the Rio Grande below Elephant Butte. A seepage run in October 1913 (Follansbee, Follett, and Gray, 1915, p.687) showed a gain in 12 cfs from Elephant Butte to Las Palomas, below Hot Springs (Truth or Consequences), a loss from there to Leasburg Dam, a slight gain from that locality to the present location of the Picacho flume, a loss to Mesquite, a slight gain to Berino, and no loss or gain from Berino to near El Paso. The total loss from Elephant Butte to near El Paso was 59 cfs. This seepage run was considered not accurate (Follansbee, Follett, and Gray, p. 689). It was made before construction of any drains.

Seepage runs were made by the U. S. Bureau of Reclamation in November 1917, January 1918, and February 1918. Figure 8, which has been taken from "Report on drainage results" by Fiock, U. S. Bureau of Reclamation, October 1919, shows the results of the three runs. The progressively smaller flow shown from November 1917 to February 1918 is due to decreasing bank storage and return of water released for irrigation during the previous irrigation season. The seepage run in February was made after the gates at Elephant Butte Dam had been closed for 2 months and thus should be more indicative of natural losses and gains. The only drains constructed at that time were portions of the East and West Drains. The graph shows a general gain as far as Salem bridge, due south of Salem, a loss from there to Leasburg Dam, a small gain from Leasburg Dam to Picacho flume, a loss from Picacho flume to Anthony bridge, and a gain from there to Courchesne bridge. For the Mesilla Valley this is about the same as is indicated by the ground-water contours on the map of June 1917 (pl. 5). In February 1918, an overall gain of about 14 cfs is indicated from south of Hot Springs (Truth or Consequences) to Courchesne bridge, consisting of a gain of 54 cfs to Salem bridge then a loss of about 40 cfs.

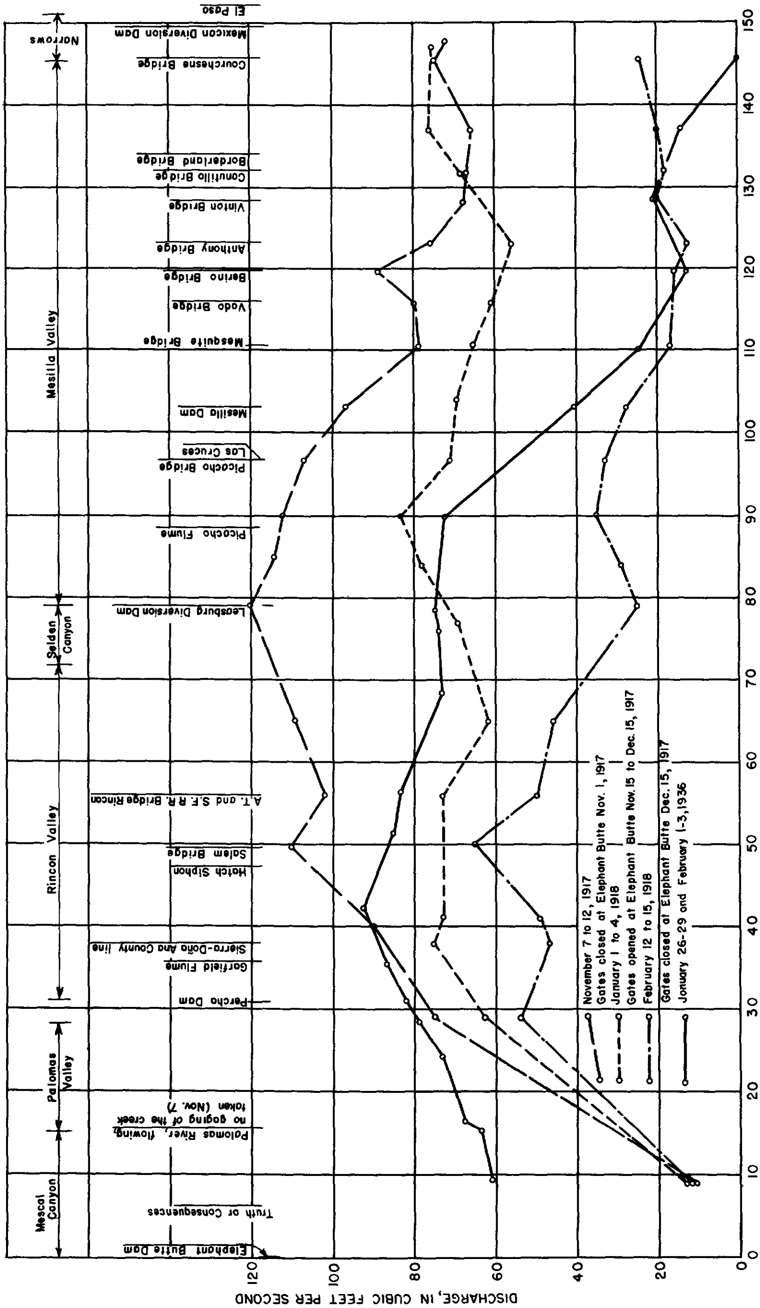

Figure 8. —Flow of Rio Grande from Elephant Butte Dam to International Dam, 1917, 1918, and 1936.

Seepage runs from Elephant Butte Dam to Courchesne bridge were made in January and February 1936 by the State Engineer's office[11]. The average results of this run, as taken from table 2, (p. 8), of the report, are given in the following table and are also shown on figure 8.

Average invisible gains and losses in the channel of the Rio Grande from Elephant Butte to El Paso, Tex., Jan. 26–29, Feb. 1–3, 1936

River section	Distance (miles)	Corrected gains and losses (cfs)			
		Section	Per mile	Stretches	
Elephant Butte Dam	0				
Mescal Canyon	2.0	-0.2	-0.10		
Above Hot Springs	5.7	+7.9	+2.14		
Below Hot Springs	9.9	+3.4	+.81		
Above Palomas Creek	15.3	+2.0	+.37		
Below Palomas Creek	16.4	+4.6	+4.18	+32.0	+32.0
Caballo P. O.	24.4	+6.0	+.75		
Caballo Dam site	29.0	+5.0	+1.09		
Percha Dam	31.3	+3.3	+1.43		
Garfield flume	36.5	+4.6	+.88		
Below County line	42.4	+5.6	+.95	+10.2	
Highway bridge, Hatch	51.1	-7.3	-.84		-8.2 Rincon Valley
Above Hatch drain	56.9	-1.2	-.21		
Selden Canyon	69.0	-10.5	-.87	-18.4	
Leasburg Dam	75.9	+.6	+.09		
Leasburg spillway	78.4	+.7	+.28	-1.7	
Picacho flume	87.4	-2.4	-.27		
Mesilla Dam	99.7	-31.6	-2.57	-31.6	
Mesquite bridge	106.5	-16.1	-2.37	-16.1	-74.3 Mesilla Valley
Berino bridge	115.9	-11.8	-1.26	-11.8	
Vinton bridge	124.9	+8.3	+.92		
Country Club bridge	132.7	-6.7	-.86	-13.1	
Courchesne bridge	140.0	-14.7	-2.01		
Total	140.0	-50.5	....		-50.5

A gain of about 42 cfs is shown from Elephant Butte Dam to below the Sierra-Dona Ana County line and a loss of about 93 cfs from there to Courchesne bridge, giving a net loss of about 51 cfs from Elephant Butte Dam to Courchesne bridge. The seepage loss in the Rincon Valley was about 8 cfs, and in the Mesilla Valley about 74 cfs.

The seepage loss from the river is especially large from Picacho flume to Berino bridge. In this section the Del Rio Drain parallels the river on the east, emptying into the river about 2 miles above Berino bridge opposite Berino. Also in this section the upper half of the La Mesa Drain and the upper third of the Chamberino Drain parellel the river on the west. The average flow of the Del Rio Drain for February 1936 plus half that of the La Mesa Drain and one-third that of the Chamberino Drain is about 71 cfs, as compared with the measured seepage loss of the river in this section of about 60 cfs.

[11] Bliss, J. H., 1936, Report on investigation of invisible gains and losses in the channel of the Rio Grande from Elephant Butte to El Paso, Tex., (unpublished), 15 pp., February 1936.

The gain in flow of the river caused by seepage to the river in the stretch from Berino bridge to Vinton bridge is in the section where four drains empty into the river. This gain may be due to seepage from the drains near their river outlets, where the water table is probably high with respect to the water level in the river. The seepage gains and losses are not constant throughout the year but rather change seasonally and yearly in response to irrigation returns and other factors.

The long-term seepage loss or gain of water from or to the river in the Rincon and Mesilla Valleys is determined by subtracting the sum of the diversions from the river plus the outflow at the lower end of the valley from the sum of the inflow at the head of the valley plus the return wastage and drain flow of the river. The resultant computed loss includes evaporation and transpiration, water that was picked up by the drains and returned to the river, and any changes in ground-water storage and net ground-water inflow or outflow from the valley. These factors, with the exception of the change in ground-water storage, also are factors in results obtained from a seepage run. As even a substantial change in ground-water storage—such as the gain resulting from irrigation in the early years and the loss resulting from installation of drains—is small when averaged over a period of years, the two methods of computation are comparable. The following table shows the net loss in the Rincon and Mesilla Valleys as determined from mean annual flows, diversions, and wastage in the two valleys from 1930 to 1946. The wastage was taken as 24 percent of the diversions, determined previously in the section on operational aspects. The seepage loss for the Rincon Valley is indicated to be about 6 cfs and for the Mesilla Valley about 76 cfs, as compared with the losses of about 8 and 74 cfs, respectively, obtained in the seepage run of February 1936—a total of 82 cfs for both methods.

Average annual seepage loss from the Rio Grande in the Rincon and Mesilla Valleys, 1930–46

	Acre-feet (in thousands)
Rincon Valley:	
Flow at Percha and Caballo Dams	(+) 835.1
Diversions at Percha Dam	(-) 91.8
Wastage (24 percent of diversions)	(+) 22.0
Return drain flow	(+) 35.4
Flow at Leasburg Dam	(-) 814.2
Seepage loss	4.5 or 6.2 cubic feet a second
Mesilla Valley:	
Flow at Leasburg Dam	(+) 814.2
Diversions at Leasburg Dam	(-) 186.9
Diversions at Mesilla Dam	(-) 310.6
Wastage (24 percent of diversions)	(+) 119.4
Return drain flow	(+) 214.0
Flow at El Paso Station	(-) 594.5
Seepage loss	55.6 or 76.2 cubic feet a second

This seepage (invisible) loss does not mean that the valleys consume ,or lose 60,000 acre-feet per year, but only that the river itself loses this amount, a part of which may be picked up by the drains discharged back into the river as visible flow. It indicates that on the whole the river replenishes the ground-water body rather than that the ground water replenishes the river. This invisible seepage loss is the excess of losses over gains in the river and may be termed a net loss.

The gross loss of water from the river in the Rincon and Mesilla Valleys may be estimated as the total of losses shown for various stretches of the river in the seepage run of 1936, equal to 102.3 cfs or about 74,000 acre-feet a year.

The relation between the flow of the river and the position of the water table is shown by Slichter (1905; p. 26). The water level in an auger hole 0.4 mile east of the river, west of Mesilla Park, rose 1.6 feet from the 1st to the 9th of October when the greatest flood recorded over a period of 10 years occurred in the river on October 5, 1904. The total rise in water level in this well was nearly 5 feet from September 19, 1904, when the river was dry, to March 26, 1905, when observations ceased. The Rio Grande had a continuous flow from the time of the flood to the end of observations. In that period of time the rise in the water table was apparent for more than 2 miles from the river.

It is probable that in certain stretches the river is perched above the water table, in which case a variation in the flow of the river will not cause an apparent change in water levels in adjacent areas.

SEEPAGE FROM CANALS

The amount of seepage from the canals varies from section to section. In some stretches of the canals where the soil is tight only small amounts of water are lost; in others where the canal traverses sandy soil the losses are quite large. No data are available as to the relative losses in various sections of the canals. Along sections where the losses are especially large, the water table rose to such high levels in 1916 and 1917 that drains were necessary. The large amount of seepage from the canals can be inferred from the large number of drains that have been constructed parallel to the canals, as shown on the accompanying maps. (See pls. 2 and 3.) This condition is particularly apparent along the upper parts of the East Side and West Side Canals.

The construction of numerous spur drains to intercept the seepage from the canals has resulted in the presence of drains along both sides of some stretches of the canals.

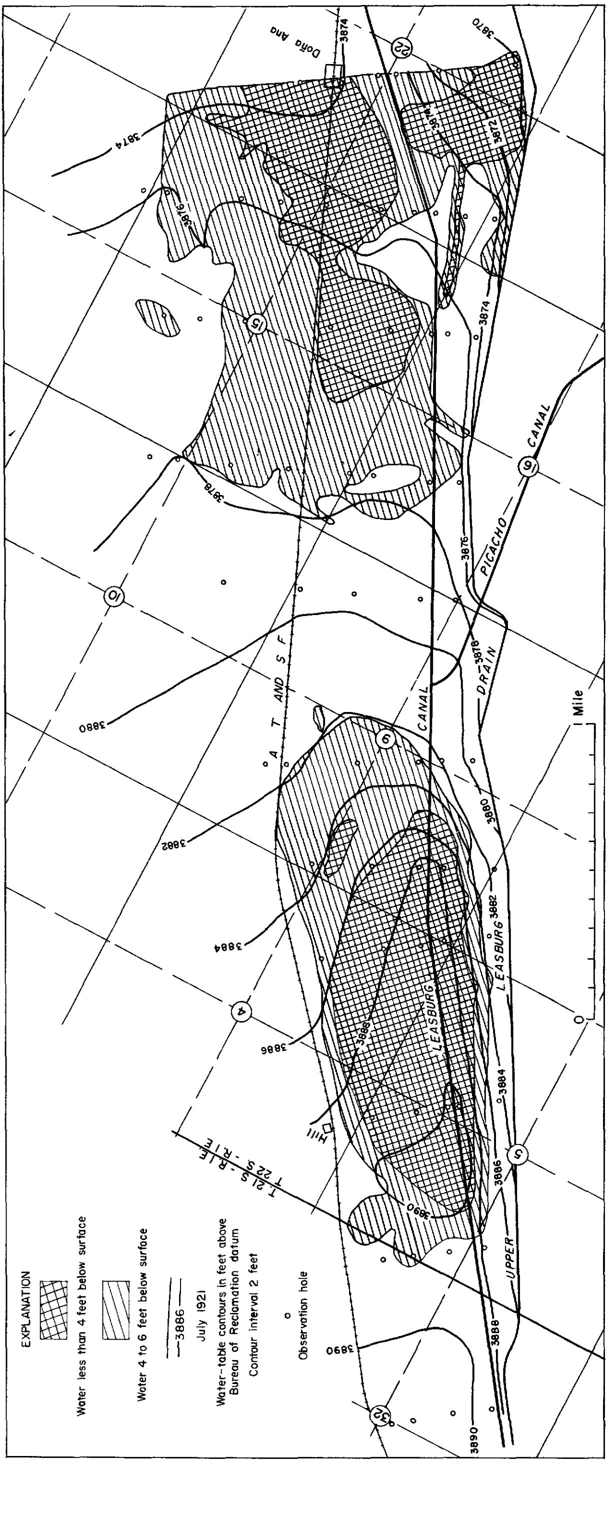

Figure 9. —Water-table contours for July 1921 in the Hill area, New Mexico, showing seepage from Leasburg Canal and high water table prior to construction of Dona Ana Drain.

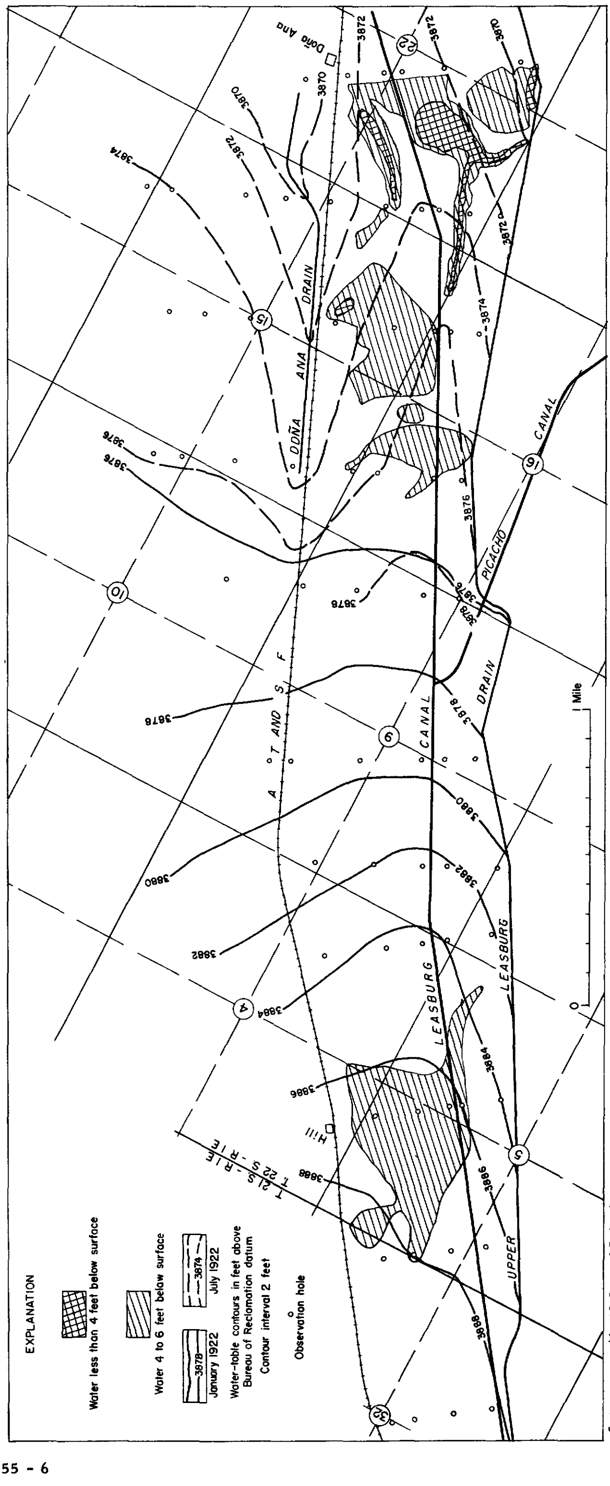

Figure 10.—Water-table contours for January and July 1922 in the Hill area, New Mexico, showing seepage from Leasburg Canal and lowering of water table during winter and by the Dona Ana Drain.

Figures 9 and 10 show the seepage from the Leasburg Canal in the vicinity of Hill. These maps, obtained from the Bureau of Reclamation, resulted from an investigation of seepage made to determine means of relieving the seeped (waterlogged) land east of the canal. Three sets of water-table contours are shown. Those for July 1921 cover the whole area and show the conditions that existed before construction of the Dona Ana Drain; those for January 1922 and July 1922 are based on data obtained after construction of this drain. The water-table contours show seepage of water from the Leasburg Canal, a greater gradient being indicated in the summer than in the winter.

Plate 9 shows the seepage from the Three Saints Lateral to the Anthony Drain in the vicinity of Berino. The map was prepared by the Bureau of Reclamation in 1924 during an investigation of the seeped land along the river. The steep gradient of the water table from the canal to the drain and the slight gradient on the west side of the canal show that most of the drain water from the west in this area is derived from the canal.

Water levels in auger hole 16, located in the west toe of the Las Cruces Lateral on the north line of sec. 2, T. 23 S., R. 1 E., have been measured monthly since 1924 by the Bureau of Reclamation. The seasonal fluctuation of the water level, plotted on plate 8, is similar in time and magnitude to that in the other auger holes located in the valley away from laterals. On the basis of a comparable range of seasonal fluctuations in well 16 and in other auger holes some distance from canals, it seems that at this spot the seepage from the canal is about equal to that which would occur from irrigated land.

It has been estimated, in a previous section of the report, that the seepage and unaccounted-for losses from the canals and laterals average about 20 percent of the gross headgate diversions in a normal year, which is equivalent to about 118,000 acre-feet a year.

RECHARGE FROM IRRIGATION WATER

A portion of the ground water in the Rincon and Mesilla Valleys is derived from irrigation waters applied to the lands in excess of the consumptive use of the crops. The amount of this excess varies with the practices of the individual farmer, the type of land, and the type of crops grown.

The interrelation of the ground water and irrigation waters has been discussed previously under "Fluctuations of the water table" and "Depth to water." The seasonal high ground-water level occurs at the end of the irrigation season and the seasonal low water level occurs just before the initial diversions for the irrigation season.

The excess of irrigation water applied to the lands in an average year has been estimated (see p.) to be about 17 percent of the gross annual diversions, or about 100,000 acre-feet a year.

RECHARGE FROM PRECIPITATION

The amount of ground water in the Rincon and Mesilla Valleys derived from rainfall upon the valley floor is probably small on the average. The normal annual precipitation at the Agricultural College is less than 9 inches, most of which occurs in the form of showers during the summer months when the evaporation and transpiration rates are high. Thus probably the greatest part is returned to the atmosphere. Some recharge to the ground water occurs from showers upon land that has been previously irrigated or from pools of rainwater that collect in shallow depressions. Also, some recharge occurs directly from precipitation in years of above-normal precipitation, such as in 1941 when the rainfall exceeded the average by more than 100 percent.

Precipitation results in cancellation of orders for irrigation water, which in turn results in a lowering of the water table. Thus, as stated previously, the net effect of a light precipitation upon the ground-water supply in the valleys is probably negative.

Figure 6 shows the water level for 1947 and part of 1948 in well 23.2E.29.214 as measured daily at 5:00 p. m. and the daily precipitation as recorded at the Agricultural College at the same location. Heavy rains in mid-August 1947 and in late February 1948 apparently caused rises of more than 0.2 foot in the water table. Precipitation in the winter months generally had little effect upon the water table because of the dryness of the soil.

DISCHARGE OF GROUND WATER

Ground water is discharged from the Rincon and Mesilla Valleys by return drain flow to the river, by direct seepage to sections of the river, by evaporation from water surfaces of the drains and ground-water ponds, by transpiration by plants in areas of shallow water, and by ground-water flow leaving the lower end of the valleys.

The amount of ground water discharged by the drains is by far the largest, about 249,400 acre-feet a year in the Rincon and Mesilla Valleys. (See table 5, p. 141.)

The direct seepage to the river occurs in a few stretches where the water table is higher than the level of the water in the river. The seepage run made in February 1936, which was discussed on pages 71-73, shows that the river gained 10.2 cfs from Percha Dam to below the Sierra-Dona Ana County line, 1.3 cfs from Selden Canyon to Leasburg spillway, and 8.3 cfs from Berino bridge to Vinton bridge, a total invisible seepage gain of 19.8 cfs or about 14,000 acre-feet a year. The present amount gained by the river is probably greater, as the level of the riverbed has lowered somewhat since the seepage run was made. (See page 68.)

The discharge of ground water by underflow at the lower ends of the Rincon and Mesilla Valleys is small. Slichter (1905, p. 9, 13) in 1904 showed that the thickness of the alluvium in the narrows of the Rio Grande a few miles above El Paso probably does not exceed 86 feet and that the ground-water flow probably does not exceed 11,200 cubic feet a day, or 94 acre-feet a year. The ground-water flow from the Selden Canyon, at the end of Rincon Valley, to the head of the Mesilla Valley is not known, but, because of the narrowness between the rock walls of the canyon and the apparent thinness of the alluvium, the flow is probably small and may be about the same as that leaving the Mesilla Valley.

Water evaporates from the drains and the small area of ground-water pools at the surface. The evaporation of ground water that is discharged to the drains is not definitely known but, on the basis of about 270 miles of drains having a width of flow of about 5 feet and an estimated annual evaporation of 4.5 feet, (National Resources Committee, 1938, p. 91, table 80) it probably amounts to about 700 acre-feet a year in the Rincon and Mesilla Valleys. The total area of ground-water pools at the surface in 1936 was determined as 51 acres in the Rincon and Mesilla Valleys. (See table, p. 20.) The ground-water discharge by evaporation from this area is therefore only about 230 acre-feet a year.

Transpiration of ground water by plants in areas of shallow depth to water may be roughly estimated from the area of native vegetation. The area of native vegetation is not definitely known but may be estimated as about 8,400 acres, on the basis of the total acreage of the valleys less the area of irrigated lands, river and canal surfaces, riverbed rights-of-way, and towns. (See p. 115.) Some of the area of 8,300 acres constituting the rights-of-way may be covered with native vegetation. If half the area of rights-of-way is assumed to be covered with native vegetation, the total area of native vegetation in the Rincon and Mesilla Valleys is about 13,000 acres. The total annual discharge of ground water by native vegetation in these valleys is, thus, about 40,000 acre-feet a year, on the basis of an average consumptive use of 3.5 feet minus an estimated 0.4 foot supplied by precipitation (National Resources Committee, 1938, p. 92, table 81).

CHEMICAL QUALITY OF WATER

GENERAL FEATURES

The chemical quality of ground water—that is, the character and amount of dissolved mineral matter in the water—is dependent upon its source, temperature, the chemical character of the water-bearing formation, and the length of time spent in flowing from the source to the point of sampling. Rainwater, which has only minor amounts of dissolved mineral matter, begins to dissolve mineral matter from the time it falls upon the ground. The part that remains on the ground as surface water generally dissolves less mineral matter than that which sinks underground to be in constant contact for long periods with the material composing the aquifer. Therefore, ground water generally contains a greater amount of dissolved mineral matter than natural surface water.

Use of water for irrigation results in loss of a part of the applied water to the atmosphere by transpiration and evaporation. This process increases the concentration of salts in the soil and in that part of the irrigation water that percolates to the ground-water body and then feeds the drains. As a result, the drain water has a higher concentration of dissolved salts than the surface water initially applied to the lands. Reuse of drain water again increases the concentration of dissolved salts in the remaining water. Therefore, an increase in dissolved salts in the irrigation waters is to be expected from the upper to the lower end of the project.

No definite limits can be set on the amount of various dissolved salts in water that will make water unsuitable for irrigation. The more dissolved solids a water contains, the less suitable it becomes for use as irrigation water. In general, the higher the concentration of salts in irrigation waters, the greater the excess of water that must be applied to the crops in order to keep the concentration of dissolved salts in the soil moisture within satisfactory limits. Certain crops are more tolerant of a high concentration of dissolved salts than others. Figure 11, from Wilcox (May 1948, p. 6), gives a classification of waters for use in irrigation. The electrical conductivity is the specific conductance of the water in micromhos at 25 C. The conductance is a relative measure of the concentration of dissolved solids, or, more specifically, of the total number of ions in the solution. A rough measure of the dissolved solids in a water can be obtained by multiplying the specific conductance in micromhos by 0.7, an average figure for waters of the Rio Grande.

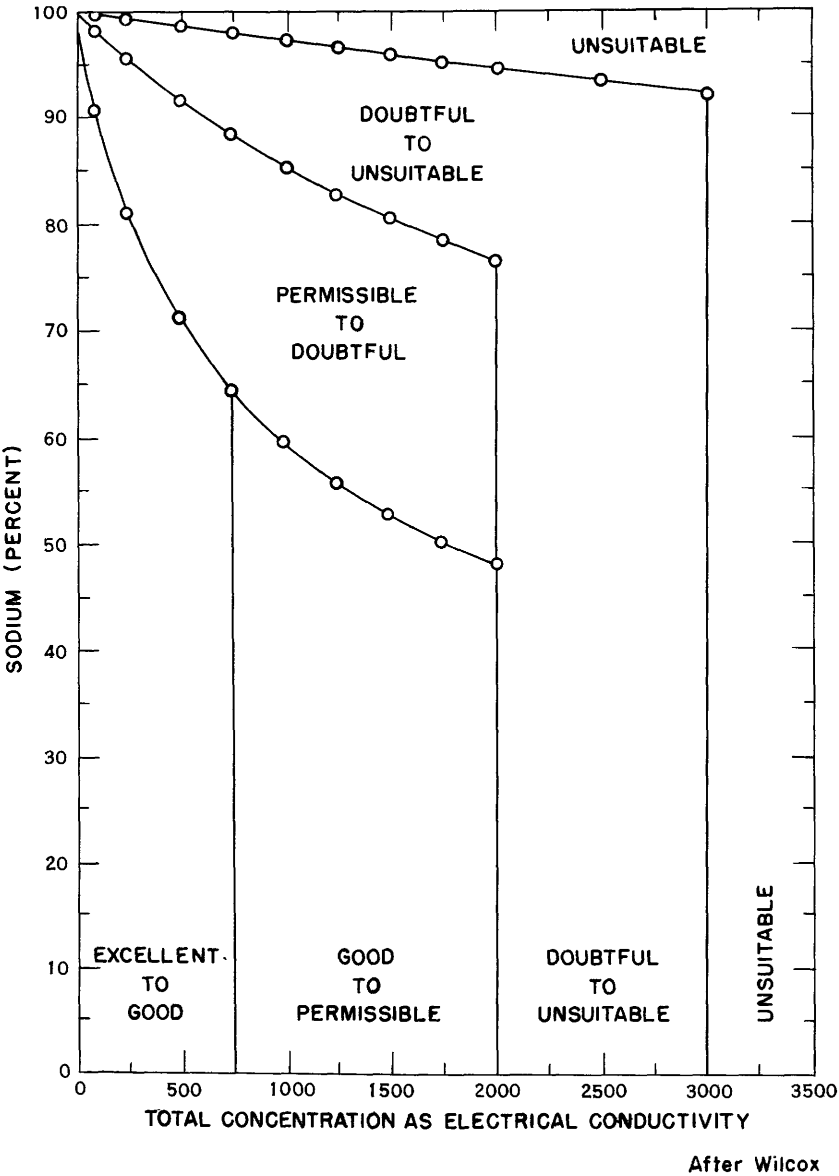

Figure 11. —Diagram for use in interpreting analyses of irrigation water.

The significance of the sodium percentage is due to the role of the basic or cation constituents in the exchange reactions that occur when water containing dissolved salts comes in contact with the soil. The use of irrigation water containing a high percentage of sodium tends to impair the physical condition of the soil whereas the use of water having a low percentage of sodium tends to maintain a good physical condition or to improve a poor physical condition that has been caused by the deflocculation of the clay fraction (Scofield, 1938, p. 5).

Thirty-four analyses of ground waters from 30 wells and 2 springs in the Rincon and Mesilla Valleys and adjacent high lands were made by the Quality of Water Branch of the U. S. Geological Survey during the present investigation. These and a few other analyses of water are reported in the table on pages 83, 86. Radium Springs is at Leasburg Dam and Derry warm springs is about a mile northeast of Derry. The wells have been separated in the table into those in the flood plain of the Rio Grande and those above the flood plain. This classification, adopted mainly to show the difference in the quality of water from the two sources, is not definite for a few wells, such as (22. 1E. 33. 321), that are along the edges of the valley floor; they are on ground that is somewhat higher than that of the valley but they actually derive water from underflow of the valley.

According to the available analyses, the water obtained from wells above the flood plain of the valley generally has less dissolved solids but a higher percentage of sodium than water obtained from shallow wells in the valley floor. However, there are numerous exceptions to this.

The ground water above the valley floor may be subdivided generally by type into: that occurring under the mesa or high land surfaces; that under the arroyo beds; and that under land adjacent to the arroyos, which may be a mixture of the other two. The type of water obtained from beneath an arroyo bed is illustrated by the water obtained from Tierra Blanca Creek near Arrey (in the wells of E. W. Powers and Mickey Plemmons), which is characterized by a small amount of fluoride and dissolved solids and a low percentage of sodium. Water from the mesas of the Santa Fe formation, as shown by the wells of A. J. Osborn (near Arrey), the Southern Pacific wells at Afton and Strauss, and those of Mrs. Annie Braidfoot in the southern part of La Mesa area, is somewhat higher in fluoride, dissolved solids, and percent sodium than the water beneath the arroyo beds. The well of J. W. Daugherty, located on the Jornada del Muerto east of Las Cruces in the Santa Fe formation, obtained particularly good water, similar to arroyo-bed water, with only 205 ppm of dissolved solids and a sodium percentage of 36.

The analyses of samples of water from the irrigation wells of Clyde Cowan and K. H. Walker indicate that the water is essentially the same as that found in the valley floor, as shown by the small amount of fluoride and the large amounts of calcium, magnesium, sulfate, chloride, and dissolved solids. These wells are close to the edge of the area of irrigated lands in the valley, on higher ground, and they probably derive a large part of their water from the underflow of the valley. Water obtained from the valley fill along the Rio Grande is generally low in fluoride and rather high in calcium, sulfate, chloride, and dissolved solids, has a moderate percentage of sodium, and is hard.

The well of C. C. Rice is on the mesa beside the railroad at Fort Selden, about a mile south of Radium Springs and above the valley floor. It reportedly hit rock at about 125 feet. The water in this well contains 3,280 ppm of dissolved solids and 74 percent sodium and is similar to the water of Radium Springs. Analysis of the water of Selden Drain (p. 86) indicates that water with a high concentration of dissolved solids and a high percentage of sodium is entering the valley in this area.

VARIATION OF QUALITY WITH DEPTH

The quality of the water in any area varies considerably both laterally and vertically. Variation in the quality of water with depth is shown in the following table. The 3 wells of different depth owned by T. L. Simpson show very poor water at the shallow depth of 42 feet, containing 1,950 ppm of dissolved solids and having a hardness of 934 ppm, and comparatively good water at the depth of 242 feet, with 297 ppm of dissolved solids and a hardness of 170 ppm. The analyses of the water in the wells of Fay Sperry and the Las Cruces Country Club, which are about a quarter of a mile apart and above the valley floor of the Rio Grande, north of Las Cruces, indicate water of better quality at lower depths. The analyses of water as reported at different depths in the domestic well 3 of the State Agricultural College indicate progressively better water with depth to 401 feet. Analyses of water from wells in the vicinity of Mesilla Park also indicate better water at depth, particularly with respect to hardness. Analyses of water from wells in the vicinity of Berino indicate very little decrease in the dissolved solids but a slight decrease in hardness at depth.

Change in quality of water with depth in localities in Mesilla Valley, N. Mex.

[Analyses by C. W. Botkin, Chemist, State Agricultural College, N. Mex., unless otherwise indicated]

Location and name	Date of collection	Depth (ft)	Dissolved solids (ppm)	Hardness (ppm)
Northwest of Las Cruces, on valley floor				
T. L. Simpson	Aug. 13, 1947[1]	42	1,950	934
Do	do	162	481	314
Do	do	242	297	170
North of Las Cruces, above valley floor				
Fay Sperry	Prior to Sept. 1936 (upper water)	78±	2,130	565
Do	do (lower water)	130	720	240
Las Cruces Country Club	February 1929	200	473	145
Do	Aug. 13, 1947[1]	200	411	214
State College, above valley floor				
Domestic well 3 (Total depth 428 feet)	1938	64	2,500	350
		73	1,070	300
		185	732	240
		230	1,054	350
		230	810	280
		300	440	145
		401	[2]510	[2]200
		401	[2]698	[2]260
		401	370	150
Mesilla Park, on valley floor				
Albert Archer	August 1925	100	450	
H. B. Elmendorf	July 1929	108	824	305
Barker well	October 1930	117	430	220
H. B. Elmendorf	July 1929	140	528	210
Albert Archer	Oct. 1, 1925	150	670	
Las Cruces Ice Co.	Aug. 13, 1947[1]	224	[3]285±	
Ray Langford	June 25, 1946	268	300	150
Berino				
Tom Locke	February 1928	40-	1,700	240
Frank Bowman	April 1927	31	707	200
Do	do	205	1,660	200
Do	May 1927	246	1,530	120

[1]Analysis by U. S. Geological Survey.
[2]Before clearing well of drilling water.
[3]Estimated from conductance.

The quality of the ground water in the area does not everywhere improve with depth. The present well of the Santa Fe Railway at Las Cruces was originally drilled to 251 feet in 1925 in search of water of a better quality than that obtained at a shallow depth. However, water of poorer quality was reportedly obtained and the well was filled back to 83 feet.

J. M. Taylor of White, Tex., reports that a well at his place in sec. 25, T. 28 S., R. 3 E., drilled to 300 feet in the valley floor near the lower end of the Mesilla Valley, obtained very poor water. He helped drill a number of wells in the same general area a number of years ago in search of water suitable for the town supply. All had poor water at lower depths, especially below 100 feet.

Mr. Paul Harvey, owner of the waterworks of White, reports that he drilled 10 or 12 wells a few years ago and 11 wells in 1946, in search of water suitable for the town supply. The wells were drilled at various localities near the town, on and above the valley floor in the Texas portion of the Mesilla Valley. The only satisfactory water was found at the location of the present supply wells in sec. 35, T. 28 S., R. 3 E. The 8 present town wells are 130 feet deep and are located between the bank of the Rio Grande, about 200 to 800 feet to the west, and the Montoya Lateral to the east, an area not more than 1,500 feet wide. Mr. Harvey reports that the wells end in a clay stratum and that poor water is found below the clay. It is probable that these wells obtain water from the river and from seepage from the lateral.

Sayre and Livingston (1945, p. 7) report that 2 test wells drilled in the Mesilla Valley, in search of a water supply for El Paso, yielded salty water. The Lippincott well, drilled to 1,074 feet in the Mesilla Valley by the city of El Paso, encountered water too highly mineralized for most purposes (Sayre and Livingston, 1945, p. 47, 106).

Slichter (1905, p. 11, 12) in his study of the underflow of the Rio Grande at the narrows at the lower end of the Mesilla Valley, found a definite increase in chloride and dissolved solids in the ground water to the observed depth of 60 feet. The dissolved solids increased from 1,690 ppm at a depth of 10 feet to 46,000 ppm at 60 feet.

VARIATION OF QUALITY AREALLY

The quality of both surface and ground waters of the area included in the Rio Grande project varies areally, being generally best at the head of the project and becoming progressively poorer toward the lower end. In the following table are given analyses of the surface water below Elephant Butte Dam, Leasburg Dam, and the El Paso gaging station, along with analyses of drain waters and individual samples from auger holes in the Mesilla and Rincon Valleys. These were taken from the detailed analyses reported in the Rio Grande joint investigation. The analyses given for the surface water at the three points on the Rio Grande are the average of the monthly averages reported for 1936 and represent closely the average quality of the surface water in that year. The analyses reported for the drain water are an average of 10 samples taken in the period 1929 to 1936 and may represent the average quality of water of the drains better than the individual sample taken in 1936. Except for the East Drain, however, the analyses show no large variation in quality with respect to time. Variation of the quality of water in the East Drain appears to be related to the change in amount of waste water present. The analyses given for the subsoil waters in the auger holes established for the Rio Grande joint investigation include only the one detailed analysis available for each hole, made in 1936. The one analysis for each hole probably does not represent the average quality of the subsoil waters at the hole but probably does give an indication of the relative quality areally in 1936 and gives some basis for comparison of the drain waters and the surface waters with the subsoil waters.

The water of the Rio Grande shows an increase in concentration of dissolved salts downstream from Elephant Butte to El Paso station. There is little change in the relative concentrations of the dissolved mineral constituents through the percent sodium shows a very slight increase.

The drain waters of the Rincon Valley seem to be nearly uniform in quality, all having, in 1936, higher concentrations of salts than the river above the Rincon Valley at Elephant Butte and below the valley at Leasburg Dam.

The waters of the various drains in the Mesilla Valley differ considerably in quality. The differences probably reflect to some extent the sources of waters in the various drains. In general the drain waters become more highly mineralized from the upper end of the valley to the lower end. However, the Selden Drain, at the upper end of the valley, has a higher concentration of dissolved solids and percent sodium than the water of the Rio Grande and of the Leasburg Drain to the south. Radium Springs (Selden Springs), in the valley just above Leasburg Dam, bring some highly mineralized ground water into the upper end of the Mesilla Valley and may form part of the accretion of the Selden Drain. The irrigation well of C. C. Rice at Fort Selden at the upper end of the valley, referred to previously, also has water of poor quality.

Analyses of water in Rincon and Mesilla Valleys, N. Mex.

[Schofield, Carl S., 1938, Quality of water of the Rio Grande Basin above Fort Quitman, Tex.: U. S. Geol. Survey Water-Supply Paper 839, p. 23, 28, 34, 264, 284-88]

Source of water	Dissolved solids		Percent sodium	Remarks
	Tons per acre-foot	ppm		
Rio Grande:				
Below Elephant Butte Dam	0.79	581	43	Average for 1936.
Leasburg Dam	.95	699	44	Do.
El Paso station	1.41	1,040	53	Do.
Drains:				
Rincon Valley:				
Garfield Drain, near outlet to river.	1.33	978	44	Average of 10 analyses, 1929-1936.
Hatch Drain, near outlet to river	1.33	978	38	
Angostura Drain, near outlet to river	1.05	773	39	
Rincon Drain, near outlet to river	1.35	993	46	Do.
Mesilla Valley:				
Selden Drain, near outlet to river	1.43	1,050	51	Do.
Leasburg Drain, above inlet to Del Rio Drain	1.01	743	42	Do.
Picacho Drain, above outlet to river	1.15	846	41	Do.
Mesilla Drain, above inlet to Del Rio Drain	1.30	956	46	Do.
Del Rio Drain, above outlet to river (includes flow of Leasburg and Mesilla Drains)	1.26	927	45	Do.
Chamberino Drain, above confluence with La Mesa Drain	2.13	1,570	55	Do.
La Mesa Drain, above confluence with Chamberino Drain	1.13	832	47	Do.
East Drain, above confluence with Anthony Drain	4.06	2,980	71	Do.
Anthony Drain, above confluence with East Drain	2.34	1,720	61	Do.
Nemexas Drain, above confluence with West Drain	2.50	1,840	64	Do.
West Drain, above confluence with Nemexas Drain	1.61	1,180	58	Do.
Montoya Drain, above outlet to river	2.33	1,710	64	Do.
Auger holes:				
Rincon Valley:				
Garfield well (206) 18.4.8.244	2.70	1,980	46	Aug. 12, 1936.
Salem well (207) 18.4.35.111	2.10	1,540	30	Do.
Hatch well (208) 19.3.10.334	1.70	1,250	77	Do.
Tonuco well (209) 19.2.35.422	2.13	1,570	33	Do.
Mesilla Valley:				
Dona Ana well (223) 22.1E.16.433	1.50	1,100	49	Aug. 12, 1936.
Picacho well (224) 23.1E.16.444	2.11	1,550	87	Do.
Mesilla well (225) 23.1E.35.211	2.06	1,520	43	Do.
Santo Tomas well (226) 24.2E.33.124	1.47	1,080	39	Do.
Chamberino well (227) 26.3E.19.113	1.28	941	38	Do.
Anthony well (228) 26.3E.34.444	3.24	2,380	65	Do.
La Union well (229) 27.3E.16.343	5.07	3,730	47	Do.
Montoya well (230) 28.3E.26.142	3.02	2,220	77	Do.

On the basis of quality, the waters of the remaining drains in the Mesilla Valley, except possibly the East Drain, which apparently has water of higher concentrations than found in the irrigation water, seem to be composed mainly of return irrigation water with some river seepage and canal wastes. There seems to be no definite relation between quality of the water and distance of the drains from the river. The drains that parallel the river and intercept the seepage from it may be called riverside drains, whereas those away from the river may be called interior drains. The water of the Del Rio Drain, which parallels the river and includes the flow of the interior drains, the Leasburg, Mesilla, and Park Drains, is comparatively good, having 927 ppm of dissolved solids and 45 percent sodium. The water of the Chamberino Drain, which is predominantly a riverside drain, has a high concentration of dissolved salts, 1,570 ppm, and 55 percent sodium, as compared to 832 ppm dissolved solids and 47 percent sodium for water of the La Mesa Drain, which is partly a riverside and partly an interior drain, in the same general area. The West Drain, which parallels the western edge of the valley, has water of poorer quality, 1,180 ppm of dissolved solids and 58 percent sodium, than that of the La Mesa Drain.

The drain in the Mesilla Valley that has water of the poorest quality appears to be the East Drain, which includes the flow of the Mesquite Drain. These drains parallel the east side of the valley from Anthony to a point north of Mesquite. The average concentration of dissolved salts in this water is 2,980 ppm with about 71 percent sodium. Waters of high sodium percentage are found in some of the wells on the side mesas, and it may be that water east of the valley toward the Franklin Mountains also has a high concentration of dissolved solids and enters the drain, or that similar water occurs in the valley in this area and has not been completely flushed by excess irrigation water applied to the lands.

The individual water analyses for the shallow auger holes in the Mesilla Valley in 1936 show a higher concentration of dissolved solids than the water of the adjacent drains. The percentage of sodium in the water is variable, being less than 40 in 4 of the holes more than 60 in 4 of the holes, and between 40 and 60 for the remaining 4 holes. If these analyses are representative, the subsoil waters have a higher concentration of dissolved solids than the drain waters. This may be true, as the drain waters are a mixture of canal waste and river seepage along with the ground-water accretion of excess irrigation water applied to the lands. As none of these holes are located between a drain and the river, their water may represent more nearly the quality of the excess irrigation water applied to the land than do the waters of the drains.

The Anthony auger hole is located at the lower end of the East Drain, which has water of poor quality. Water from the Anthony hole also is of poor quality but apparently not as poor as that in the drain. As the hole is west of the drain it is not evident whether poorer water is entering the drain from the east or from other areas along the drain above the hole.

QUALITY OF LAS CRUCES WATER SUPPLY

The water supply of Las Cruces prior to 1937 was obtained from 2 wells, 75 and 100 feet deep, drilled in the valley floor. As water from these wells was very hard (hardness about 500 ppm) a new supply was developed east of the town, from wells drilled between 2 arroyos on the pediment overlooking the valley. Water obtained from this source originally had less than half the hardness of the former supply. Additional wells have gradually been added at this new location to a total of 5 in 1947, all within a radius of about 150 feet. Pumping of these wells has resulted in a lowering of the water level below that in the valley. The original water level is not definitely known but was probably slightly above that in the valley. The trough in the contours of the water table in the vicinity of the city wells, as shown on the water-table map of Dona Ana County (pl. 1), indicates that a lowering of at least 10 feet has probably occurred. This lowering will cause a greater proportion of the pumped water to be drawn from the valley and will eventually cause an increase in the hardness and dissolved solids of the city supply. The following tabulation of the quality of water of the city supply indicates that a slight increase in dissolved solids may have taken place at the present location, as shown by the analysis of the hydrant water in 1939 and that from well 2 in 1948. Analyses in May 1947 and in March 1948 of the water from the new city well 5 also show an increase in dissolved solids and hardness. These increases may indicate that a progressively greater part of the water in the wells is being drawn from the valley.

Change in chemical quality of city water supply of Las Cruces, N. Mex., 1918–48

[Note: Water supply prior to 1937 obtained from two wells, 75 and 100 feet deep, drilled on valley floor. Beginning in 1937, water obtained from wells located on high ground east of city]

Source	Date	Hardness (ppm)	Total dissolved solids (ppm)	Sodium (percent)
Hydrant	Aug. 15, 1918[1]		913	
Do	1930[1]	501	943	36
Do	1934 (?)[1]	485	970	35
Do	November 1935[1]	527	1,012	34
Hydrant[2]	May 11, 1939[3]	210	403	
City water	May 6, 1942[1]	160	490	
City well 2	Mar. 25, 1948[3]	248	442	36
City well 5	May 6, 1947[3]	441	747	32
Do	Mar. 25, 1948[3]	482	770	27

[1]Analyzed by C. W. Botkin, chemist, State College, N. Mex.
[2]Hydrant water at Pueblo Courts.
[3]Analyzed by U. S. Geological Survey.

The concentration of dissolved solids in the new city well 5, more than 750 ppm, and hardness of more than 440 ppm approach the concentration of the waters in the valley in this area. Well 5 when originally completed was screened from 262 to 285 feet but because of the small discharge, about 50 gallons a minute, the casing was later perforated from 210 to 250 feet. The poorer water is evidently entering the well at the higher level. The casing record for well 2 is not known but is presumedly about the same as for wells 1, 3, and 4, which have 20-foot screens set near the bottom of the wells, at about 300 feet.

SUMMARY OF QUALITY OF WATER

In conclusion, the quality of water obtained by wells of moderate depth in the valley floor is similar to that in the drains and somewhat poorer than river water. The dissolved solids in the ground water at moderate depths in the Rincon and Mesilla Valleys may average about 1,000 ppm, with 35 to 50 percent sodium. This water is suitable for irrigation, although not as good as river water, being classed as good to permissible. (See fig. 11.) In general, deeper wells in the Mesilla Valley supply better water. One notable exception is in the lower end of the Mesilla Valley where the quality apparently becomes worse with depth. Some shallow waters in various areas are particularly poor. The quality of the water is evidently poorer at the lower ends of the Rincon and Mesilla Valleys than at the upper ends, except in the vicinity of Radium Springs.

The quality of water obtained by wells drilled in the Santa Fe formation flanking the valleys is generally potable, with dissolved solids of about 500 to 700 ppm and a hardness of generally less than 200 ppm. The sodium content is generally high, about 70 percent, and the fluoride in some localities is quite high, more than the 1.5 ppm generally considered the safe limit for growing children to escape mottled teeth (Public Health Service, 1946, p. 371-384).

The best water in the area, with respect to dissolved mineral matter, apparently occurs under the arroyo beds where the comparatively fresh flood waters from the hills and the mesas sink into the ground. This water probably contains, on the average, less than 300 ppm of dissolved solids, less than 200 ppm hardness, and only minor amounts of fluoride.

The source of the comparatively good water at depth in many localities of the Mesilla Valley is probably the side inflow from the bordering mesas. This may be particularly true at the outlets to the arroyos, which at various times have flooded and built alluvial fans extending into the valley. These fans may have thin clay lenses extending from the arroyo mouth into the valley under which fresher water may have been stored.

HYDROLOGIC CHARACTERISTICS OF WATER-BEARING FORMATION

GENERAL CONDITIONS

In order to properly evaluate the amount of flow of underground water and the long-term effects of pumping, two important hydrologic characteristics of an aquifer, the coefficients of transmissibility and storage, must be known. The storage coefficient under water-table conditions is approximately equal to the specific yield.

The ease with which water moves through an aquifer depends upon the interconnection and size of the pore spaces and to some extent upon the temperature of the water. The coefficient of transmissibility, which expresses the rate of flow, is defined as the quantity of water in gallons a day that will percolate under the prevailing temperature through a vertical strip of the aquifer 1 foot wide, oriented perpendicular to the direction of flow of the water, under a unit hydraulic gradient.

Not all the water stored in an aquifer is available to wells. Only a portion of the water filling the pore spaces will drain out under the action of gravity. The specific yield of an aquifer is a measure of the ability of the aquifer to release water to wells under the action of gravity. It is defined as the ratio, expressed as a percentage, between the volume of water that a saturated aquifer would yield by gravity and its own volume. As not all the water drains from the aquifer, the specific yield is somewhat less than the porosity of an aquifer. The larger the size of the pore spaces the larger the specific yield. Clay has a large porosity but a very small specific yield as a result of the minute size of the pore spaces. If the specific yield of an aquifer were 25 percent, then a decline of water level of 1 foot would represent a quantity of water of a depth of 0.25 foot distributed over the area of the aquifer.

COEFFICIENT OF TRANSMISSIBILITY

METHODS OF DETERMINING

The coefficient of transmissibility can be determined either in the laboratory or in the field by computations based on the rate of discharge of the water in relation of the gradients. Exact determination of the coefficient is difficult; of the several known methods, the two used in this investigation as described below.

One of the field methods of determining the coefficient of transmissibility is that developed by Theis (1935, p. 522), which consists of pumping a well at a constant rate for a period of time and noting the rate of recovery of the water level in the well after pumping has ceased. The coefficient of transmissibility is then computed by means of the following formula:

$$T = (264\ Q/s') \log_{10} (t/t')$$

in which

T = coefficient of transmissibility, defined above.
Q = discharge rate of well, gallons per minute.
s' = residual drawdown in well at time t', in feet.
t = time since pumping started.
t' = time since pumping stopped.

If the pump has been operated for periods previous to the period of pumping immediately preceding the measurement of recovery of water level, then these previous periods of pumping can be taken into account by modifying the formula as follows:

$$T = 264\ (Q/s') \log_{10} \frac{t_1 \cdot t_2 \cdot t_3 \cdots t_n}{t_1' \cdot t_2' \cdot t_3' \cdots t_n'}$$

in which t_1, t_2, t_3, t_n = time since the beginning of previous periods of pumping

and t_1', t_2', t_3', t_n' = time since the end of previous periods of pumping

Theoretically, the equation applies only to an aquifer of infinite areal extent that is composed entirely of homogeneous sediments, in which a well penetrates the entire thickness of the aquifer, and in which the coefficient of transmissibility is constant at all times and places.

In practice almost none of these conditions is completely fulfilled. However, in most aquifers the departures from the theoretical conditions are small enough to allow use of the formula to obtain workable results.

As the aquifer in the Rincon and Mesilla Valleys is composed of sediment deposited by a meandering stream, the deposit is not homogeneous in either vertical or horizontal extent and therefore the coefficient of transmissibility will vary from locality to locality, even within a short distance. This necessitates the determination of the coefficient of transmissibility at as many points as feasible. No aquifer is of infinite areal extent; however, the horizontal extent of an aquifer can usually be considered as infinite for short periods of pumping. Failure of wells to penetrate the full thickness of the aquifer causes some error but this error is considered to be small so long as the drawdown is not too large a percentage of the saturated formation penetrated by the well and the well casing is perforated at all water-bearing formations.

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The rate of accretion of ground water to a drain is dependent upon the coefficient of transmissibility of the aquifer and the slope of the water table to or from the drain. Given the rate of gain in flow of a drain in cubic feet per second per mile and the sum of the average gradients of the water table to each side of the drain, expressed as a decimal, the transmissibility of the aquifer can be determined from the following formula:

$$T = \frac{\text{Gain in flow} \times 122}{\Sigma\,\text{Gradient}}$$

Gradients of the water table to the drain are considered positive; those away from the drain are negative. Gradients must be selected where the water table has a nearly constant slope, far enough from the drain to be uninfluenced by the sharp change in slope of the water table that occurs near the drain. (See fig. 14.) Also, water must not be added to the water table between the drain and the points of measurement of the slopes.

In practice, determination of the coefficient of transmissibility from any individual set of measurements is subject to error because of addition to the ground water by return irrigation water at points between the drain and the wells used for measurement. An average of the values determined at monthly intervals for a period of a year would probably approach the correct value for the coefficient of transmissibility.

PUMPING TESTS

The coefficient of transmissibility was determined by the Theis method (p. 91) by noting the recovery of water levels in 4 wells on the floors of the Rincon and Mesilla Valleys, and in 3 wells on the higher lands bordering the valleys. The curves of the recovery of the water level obtained from the 7 wells are given in figures 12 and 13.

The irrigation well of B. S. Thurman, in the Rincon Valley, sec. 4, T. 19 S., R. 3 W., located in the valley bottom about 1,500 feet north of the river and about 300 feet south of the bluff of the mesa, was pumped at the rate of about 660 gpm for 4 days, after which the rate of recovery of the water level was measured. This well is only 52 feet deep and reportedly ends in a gravel bed. The maximum drawdown was 8.9 feet, 13.5 feet below the land surface at the end of the 4 days' pumping. The coefficient of transmissibility as determined from the recovery rate of the water level was 136,000 gpd per foot. It is probable that if the well had been deeper a slightly larger value for the coefficient of transmissibility might have been determined. However, the value determined is high and is probably representative of the unconsolidated riverbed deposits.

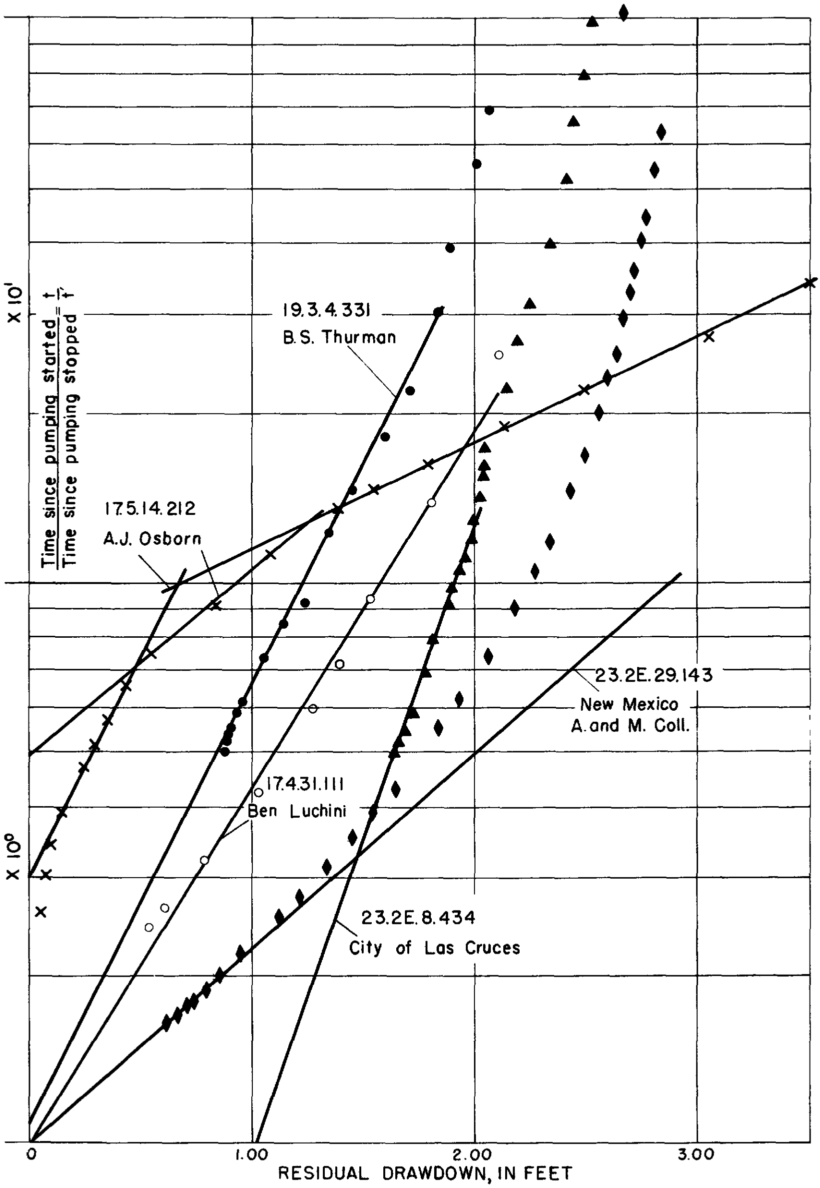

Figure 12. —Curves of recovery of water levels obtained by pumping tests on five wells in Rincon and Mesilla Valleys.

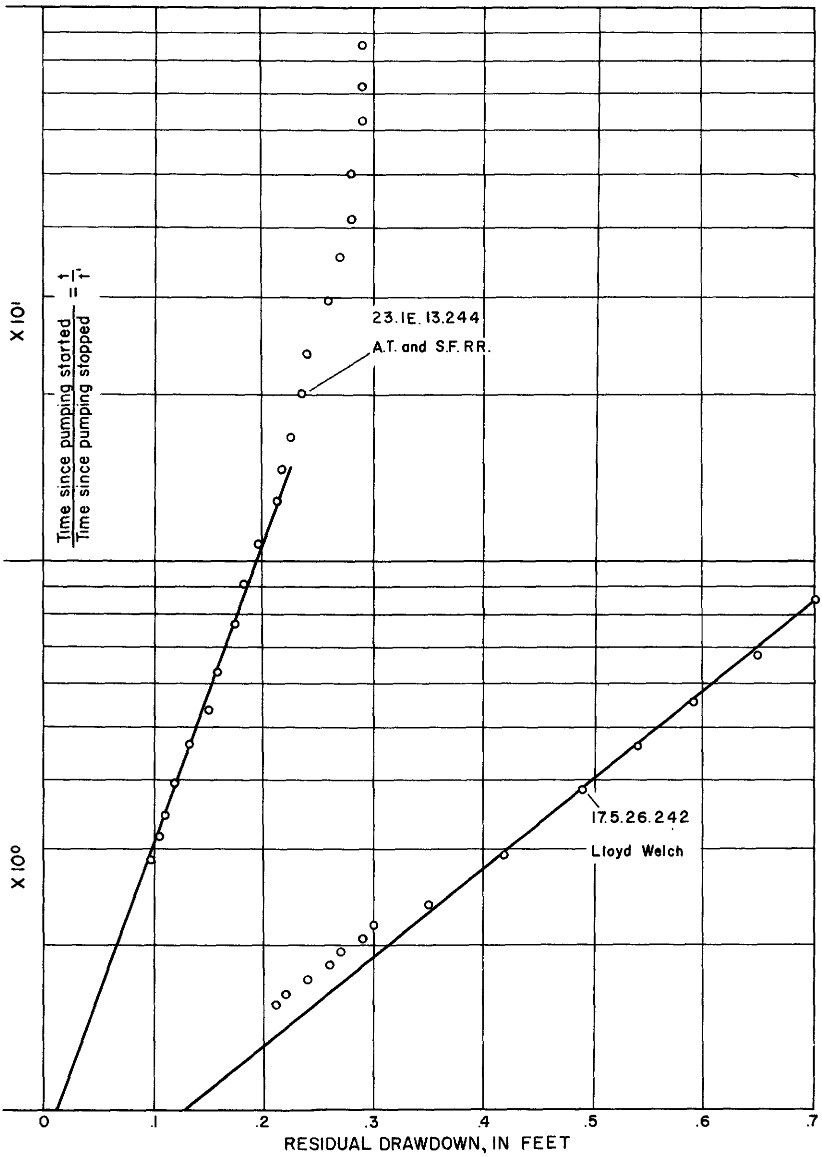

Figure 13.—Curves of recovery of water levels obtained from pumping tests on two wells in Rincon and Mesilla Valleys.

The irrigation well of Ben Luchini, also in the valley bottom of the Rincon Valley, sec. 31, T. 17 S., R. 4 W., about 1,000 feet east of the river, was pumped for about 9 hours with a discharge of about 1,000 gpm and a drawdown of about 14 feet. The well had been pumped on previous days also. The coefficient of transmissibility determined from the recovery of the water level was 167,000 gpd per foot, which is quite high.

The water supply well of the Atchison Topeka & Santa Fe Railroad at Las Cruces was pumped for 15 hours at an average rate of about 64 gpm with a drawdown of 3.9 feet. This well at present is reported to be 83 feet deep but originally it was drilled to 251 feet. The coefficient of transmissibility was determined as 91,000 gpd per foot. This value may be slightly lower than actual, as it is probable that the sediments were not completely drained because of the small drawdown. However, the value determined is probably of the right order of magnitude for the sediments. The low specific capacity of this well compared with the high coefficient of transmissibility suggests that the perforations in the well casing are encrusted, causing a large entrance loss of head of the water.

The irrigation well of the State College, 23.2E.29.143, located on the valley floor, was pumped for 24 hours at an average rate of 1,270 gpm with a drawdown of 13 feet, to 26 feet below the land surface. The well was reportedly drilled to 50 feet. The value of the coefficient of transmissibility determined from the recovery of the water level was 116,000 gpd per foot. As the drawdown in this well was a large percentage of the depth of the well, it may be that the actual value of the coefficient of transmissibility is slightly higher. However, as stated for the other wells, the value obtained is high and is what might be expected for the sediments.

The irrigation well of A. J. Osborn in sec. 14, T. 17 S., R. 5 W., was pumped at 250 gpm for about 7 hours with a drawdown of about 23 feet from the static level of 60 feet. This well is near the northern end of the Rincon Valley, on the north side of Montoya Arroyo above the valley floor. The value obtained for the coefficient of transmissibility was about 13,000 gpd per foot. However, this figure may not be correct because recovery of the water level did not conform to theory, the curve obtained being composed of essentially 3 straight segments. (See fig. 10.) Other portions of the recovery curve yielded values of 22,000 and 51,000 for the coefficient of transmissibility. It is evident, though, that the formation is less permeable than that of the valley floor.

Another irrigation well above the valley floor, belonging to Lloyd Welch, was pumped at 700 gpm for 10 hours with a drawdown of

9 feet. This well is on the south side of Tierra Blanca Creek in sec. 26, T. 17 S., R. 5 W., about 2 miles south of the Osborn well. The coefficient of transmissibility obtained from the recovery of the water level was 298,000 gpd per foot, which is very high. This well reportedly penetrated 43 feet of good gravel below the water level in a total depth of 88 feet, which may account for the high value obtained on this short test. It is probable, had the pump been operated for a longer time, the effect of the pumping would have reached beyond the extent of the gravel stringer and a smaller value of the coefficient of transmissibility would have been obtained.

The new city well 5 of Las Cruces, drilled to 300 feet, was pumped for 3½ days at 250 gpm. The maximum drawdown of water level was about 12 feet below the static level of about 186 feet below land surface. The value of the coefficient of transmissibility as determined from the recovery of the water level was 73,000 gpd per foot. This well is located on the bluff east of Las Cruces, out of the valley, in sediments of the Santa Fe formation. The value of the coefficient of transmissibility determined from this well is possibly higher than the average for the bordering mesas.

The following table summarizes the figures of the coefficient of transmissibility determined from pumping tests on the wells.

Coefficients of transmissibility determined from pumping tests on wells in the Rincon and Mesilla Valleys

Well location number	Name of owner	Discharge (gpm)	Drawdown (ft)	Specific capacity (gpm per ft)	Coefficient of transmissibility (gpd per ft)
	On valley floor				
17.4.31.111	Ben Luchini	1,000	14	71	167,000
19.3.4.331	B. S. Thurman	660	9	73	136,000
23.1E.13.244	A. T. & S. F. Ry.	64	4	16	91,000
23.2E.29.143	New Mexico College of A. & M. A.	1,270	13	98	116,000
	Above valley floor				
17.5.14.212	A. J. Osborn	250	23	11	13,000
17.5.26.242	Lloyd Welch	700	9	78	298,000
23.2E.8.434	City of Las Cruces	250	12	21	73,000

WATER-TABLE GRADIENTS AND FLOW OF DRAINS

The coefficient of transmissibility was determined also by correlation of the slopes of the water table to a few drains and the flow of the drains, in order to have an independent check upon the coefficients of transmissibility determined from the pumping tests on wells.

Two lines of auger holes were installed in February 1947 across the Park Drain, along Holt and Seale roads about 5 miles south of Las Cruces, extending about 1,800 feet to 2,900 feet from both sides of the drain. Water-level measurements were made at intervals of 2 weeks in the auger holes and the gain in flow of the drain between the 2 hole lines was measured every month by Mr. Williams or Mr. Carbine of the U. S. Bureau of Reclamation. Values of the coefficient of transmissibility were determined every month by using the gradient of the water table determined from the measurements made on the auger holes within a few days of the measurement of the gain in flow of the drain in that section. If conditions were ideal, that is, if equilibrium of the water table and the drain were established and all measurements were accurate, it would be expected that the coefficient of transmissibility determined every month would be the same. However, application of irrigation water to the lands during the growing season results in an unstable condition not only between the water table and the drain but of the water table at the points of observation. The result is a range of figures for the coefficient of transmissibility determined every month. An average of the figures for 12 months, a full cycle, is expected to approach the true magnitude of the coefficient of transmissibility. The figures are given in the following table along with the water-table gradients on each side of the drain and the gain in flow of the drain between the 2 hole lines, which has been converted to accretion per mile as the 2 hole lines are 6,800 feet apart. Also, as the southern auger hole line is not perpendicular to the drain, the gradients on this line have been multiplied by 1.765 to convert the figures to a gradient perpendicular to the drain. The elevations of the water level are in feet above the 3,800-foot level of the U. S. Bureau of Reclamation datum. The hole numbers indicate the distances of the auger holes from the drain, in feet. The slope of the water table to the drain for several months is given in figure 14. The magnitudes of the coefficient of transmissibility obtained for each month ranged from 52,500 to 116,000 with an average of 76,000 gpd per foot.

The U. S. Bureau of Reclamation at various times has made studies of the drainage conditions in local areas. The studies included establishment of lines of auger holes across certain stretches of the drains. These studies were made a number of years ago, and not all the data are available. Measurements of water-table elevations in holes as shown on water-table profiles across 6 drains were complete enough to be of some use in determining the coefficient of transmissibilities. The location of some of the auger-

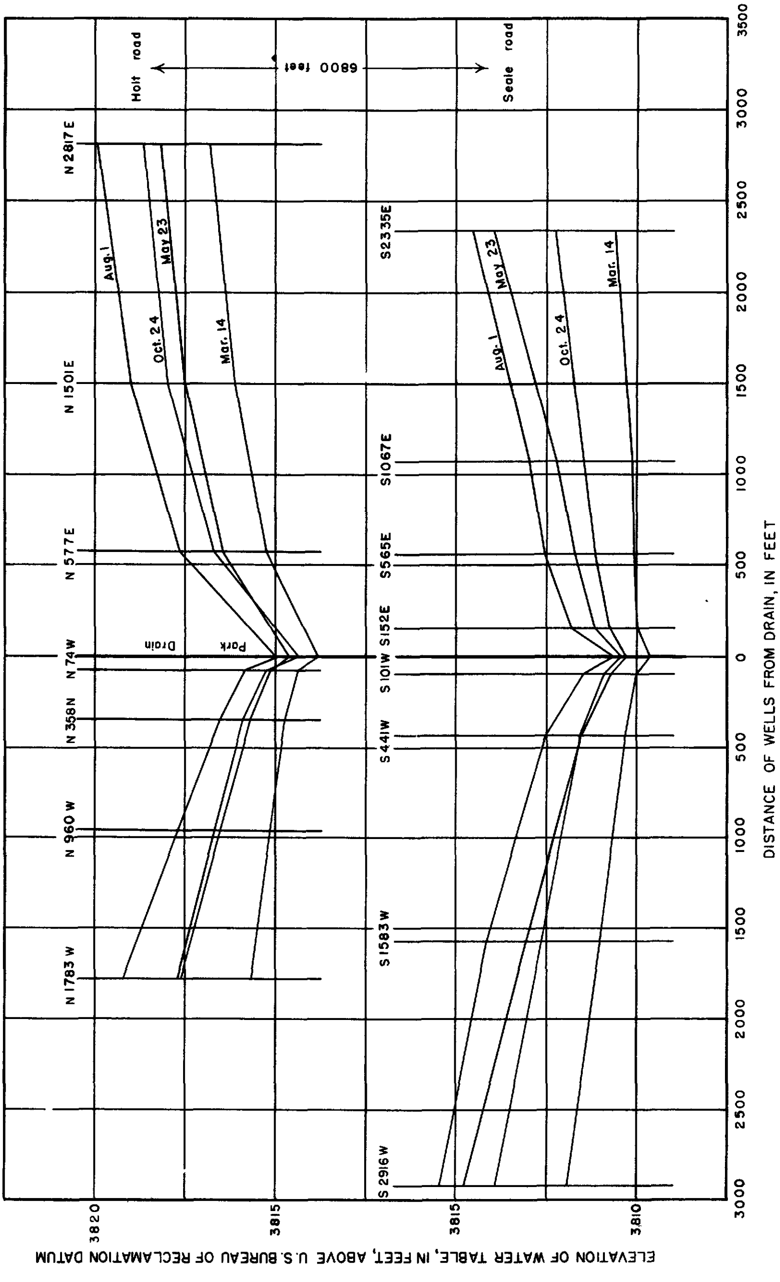

Figure 14. — Profiles of water table across the Park Drain for selected times in 1947, as measured in auger holes in two lines about 3 miles south of Mesilla Park.

Computation of coefficients of transmissibility determined from gain in flow of Park Drain and water-table gradients on 2 auger hole lines along Holt and Seale roads across Park Drain, about 3 miles south of Mesilla Park

[Gradients on south line have been corrected by multiplying by 1.765 to correct gradient perpendicular to drain]

No. of computation	Date	Water-table gradient to drain and date of measurements: Holes west of the drain: Holes N1783W and S2916W (Elevation of water table, feet above datum)	Holes N358W and S441W (Elevation of water table, feet above datum)	Gradient to drain	Holes east of the drain: Holes N2817E and S2335E (Elevation of water table, feet above datum)	Holes N557E and S565E (Elevation of water table, feet above datum)	Gradient to drain	Double average gradient	Accretion to drain (cfs per mile) and date	Computed transverse coefficient of transmissibility (gpd per ft)
	1947								1947	
1	Feb. 14	15.86	14.83	0.00072	17.07	15.39	0.00075		Feb. 18	
		12.27	10.47	.00128	10.89	10.20	.00069	0.00172	0.74	52,500
2	Mar. 14	15.68	14.75	.00065	16.82	15.28	.00069		....	
		11.95	10.35	.00114	10.61	10.10	.00051	.00149	[1]1.65	53,000
3	Apr. 11	17.11	15.36	.00123	17.69	16.18	.00067		Apr. 15	
		12.77	11.19	.00112	12.08	10.81	.00126	.00214	2.04	116,000
4	May 23	17.63	15.73	.00133	18.16	16.46	.00076		May 20	
		13.93	11.57	.00168	13.95	11.74	.00220	.00299	1.96	80,000
5	June 19	17.92	15.84	.00146	18.34	16.69	.00074		June 23	
		14.30	11.86	.00174	14.71	12.07	.00263	.00328	1.66	61,800
6	Aug. 1	19.20	16.55	.00186	19.90	17.66	.00100		July 28	
		15.48	12.50	.00212	14.60	12.53	.00206	.00372	2.66	87,200
7	Sept. 12	18.86	16.43	.00171	19.47	16.39	.00138		Sept. 9	
		16.40	12.61	.00270	13.92	12.19	.00173	.00376	2.71	87,900
8	Oct. 24	17.72	15.89	.00128	18.67	16.73	.00087		Oct. 23	
		[1]14.80	11.58	.00230	12.25	11.18	.00107	.00276	1.89	83,600
9	Nov. 21	17.17	15.71	.00116	18.17	16.28	.00084		Nov. 24	
		14.06	11.30	.00197	12.85(?)	10.96	.00188	.00292	2.09	87,100
	1948								Dec. 26	
10	Jan. 2	16.57	15.28	.00091	17.53	15.85	.00075		1.10	
		13.07	10.89	.00155	11.38	10.64	.00074	.00198		67,500
11	Feb. 13	16.13(?)	15.03	.00077	17.09	15.58	.00067		Feb. 16	
		12.28	10.54	.00124	10.85	10.28	.00057	.00162	0.77	58,000
Average										75,900

[1] Estimated.

hole lines along the drains was not given. Some profiles had only a few holes, whereas others had as many as 18 across the drain in question. The gain in flow of the drain was not given in any case. To determine the water-table gradients the change in water level in a distance on each side of a drain on each auger-hole line was noted. All the gradients for the cross sections of a particular drain were then averaged and doubled. The average gain in flow of the drain through the section of the auger-hole lines was assumed to be equal to the average accretion of the drain as a whole for the particular month. The coefficients of transmissibility so obtained are of course subject to many errors but should show the magnitudes to be expected.

By using water-table gradients obtained from 4 auger-hole lines across the Rincon Drain, covering a distance of 4,430 feet along the drain, for an unknown month in 1926 and the mean accretion per mile for the total length of the drain for 1926, a mean coefficient of transmissibility of 96,000 gpd per foot was obtained. The coefficient of transmissibility determined from using the month having the minimum accretion to the drain was 64,000 and that for the month having the maximum accretion was 134,000.

Water-table gradients were available for 18 auger-hole lines, established in July 1930, that extended eastward from the drain to the river along nearly the entire length of the Picacho Drain. Gradients to the west of the drain were not given but as the drain is mainly a riverside drain and probably receives most of its seepage from the river to the east, the gradients on the west side were assumed as being 0.4 of those on the east side. By using the average accretion per mile of the drain for its total length for July 1930, a coefficient of transmissibility of 77,000 gpd per foot was obtained.

The average of water-table gradients for May and August 1927 was obtained on nine auger-hole lines extending on both sides of the West Drain. By using the average accretion of the West Drain for its total length, for the months May through August 1927, a coefficient of transmissibility of 135,000 gpd per foot was obtained.

Water-table gradients for July 1930 were obtained for 9 auger-hole lines across the lower portion of the Del Rio Drain near Mesquite, 6 lines of which extended on both sides of the drain. By using the average gain in flow of the Del Rio Drain for its full length for July 1930, 2.8 cfs per mile, a coefficient of transmissibility of 60,000 gpd per foot was obtained.

The total length of the Del Rio Drain includes about 11 miles of the Park Drain, an interior drain. The average gain in flow of the Park Drain is undoubtedly less than that of the Del Rio Drain, which parallels the river. If it is assumed that the accretion of the Park Drain is about the same as that of the Mesilla Drain, also an interior drain, which for July 1930 was 0.8 cfs per mile, then a correction of 9 cfs is to be subtracted from the flow of the Del Rio Drain. The flow of the Del Rio Drain is then about 81 cfs for 27 miles or a gain in flow of about 3.0 cfs per mile. The coefficient of transmissibility, using this value of the accretion, is 64,000 gpd per foot, not essentially different from the 60,000 obtained above.

Water-table gradients were obtained for July 1930 for 7 auger-hole lines along the Mesquite Drain extending west from the drain, north of the town of Mesquite. Gradients east of the drain were estimated and the average gain in flow per mile of the East Drain, into which the Mesquite Drain empties, for the month of July 1930 was used. The coefficient of transmissibility so obtained was 47,000 gpd per foot, which is not reliable because of the large number of assumptions used.

Water-table gradients were obtained for July 1930 for 11 auger-hole lines that extended west toward the river along the lower $2\frac{1}{2}$ miles of the Anthony Drain. Gradients east of the drain were estimated and the average gain in flow of the drain for its full length for the month of July 1930 was used. The value of the coefficient of transmissibility obtained was about 54,000 gpd per foot.

The coefficients of transmissibility obtained from the profiles are given in the following table. Part of the variance in the coefficients is due to assuming that the water-table gradients obtained were representative of the drain as a whole or that the average accretion for the drain as a whole was equal to that through the stretch covered by the auger-hole lines; in a few cases it is due to estimation of the gradients on one side of the drain. As these drains are in widely separated parts of the valleys, a range in values of the coefficient of transmissibility is to be expected from the nature of the sediments.

The coefficients of transmissibility obtained by correlation of water-table gradients to several drains with accretion to the drains are somewhat less than those obtained from the pumping tests. This may be caused by the stratification of the sediments, which would reduce the depth of the effect of the drains. Because the coefficient of transmissibility is the product of the thickness of the aquifer and

Coefficients of transmissibility determined from auger-hole profiles across various drains in the Rincon and Mesilla Valleys

Drain	Length of drain (miles)[1]	Length of section (miles)	Double average gradient	Accretion to drain (cfs per mile)	Coefficient of transmissibility (gpd per ft)
Rincon..........	6.5	0.8	0.0022	1.75	96,000
Picacho..........	7.3	5.3	.0030	1.90	77,000
West.............	28.3	2	.0019	2.1	135,000
Del Rio..........	[2]37.7	3	.0057	2.8	60,000
Mesquite........	[3]22.8	2.5	.0031	[3]1.2	47,000
Anthony.........	7.9	2.5	.0025	1.1	54,000
Average........					78,000

[1]Length at time of measurement of water-table profile.
[2]Includes Park Drain, an interior drain.
[3]East and Mesquite Drains.

the permeability of the aquifer, the resulting value obtained from the drains might be expected to be lower than that obtained from wells. Also, the coefficient of transmissibility obtained from the drains is a transverse transmissibility, across the valley, which perhaps is less than the transmissibility along the valley.

It seems probable that the average coefficient of transmissibility for the alluvial valley fill as a whole can be taken as 75,000 gpd per foot. On the basis of the poor performance of wells on the higher lands bordering the valley as compared with those in the valley and pumping tests on wells in the Santa Fe formation in this and other areas, it appears that the coefficient of transmissibility of the higher lands bordering the valley is less than half that of the alluvium in the valley and probably does not exceed 30,000.

SPECIFIC YIELD

The specific yield of an aquifer, defined on page 90, is a measure of the ability of the aquifer to release water to wells under the action of gravity and is difficult to determine either in the field or in the laboratory. Determination depends upon many factors that cannot be readily evaluated. The percentage of water in an aquifer that can be drained by gravity depends not upon the amount of pore space but upon the size of the connecting pore spaces. Also, the amount of water drained is dependent upon the length of time drainage takes place. In well-sorted sands the porosity is fairly large, possibly approaching 50 percent, and a large percentage of the available water would drain out, under the force of gravity, in a short time. However, it is problematical when complete drainage would take place—probably a matter of years. The longer drainage takes place, the greater the volume of water recovered from a given volume of an aquifer. Owing to the effect of capillarity, a lowering of the water table by a short period of pumping represents less extraction of water from the sediments than would occur from an equal lowering of water level by a long period of pumping.

In well-sorted gravels, which have a porosity about equal to that of sand, the percentage of water draining out in a short time would be larger than for sand. Clays in general have a high porosity but because of the small size of the grains and pores the capillary forces are large and the amount of water that will drain by gravity may be negligible.

The alluvial fill of the Mesilla and Rincon Valleys is variable and consists of mixtures of sand, gravel, silt, and sandy clay, as well as some lenses of well-sorted gravel or sand. The specific yield of such sediments also would be variable.

The specific yield of eight various sands tested by Hazen (Meinzer, 1923, p. 54) ranged from 23 to 37 percent. The specific yield for 36 samples from the fill of major stream valleys of San Diego County, Calif., was estimated by Lee (Meinzer, 1923, p. 60) as between 33 to 37 percent by volume, with a practical value of between 20 and 25 percent.

Probably a specific yield of about 25 percent would be an average for the valley fill as a whole in the Rincon and Mesilla Valleys.

GROUND-WATER DEVELOPMENT

PREVIOUS DEVELOPMENT

Pumping of ground water from wells for irrigation in the Mesilla Valley is not new but, as indicated by Follett, was practiced as long ago as about 1896 by a man named Schiller, who irrigated about 800 acres that had been formerly served by the Dona Ana ditch (National Resources Committee, 1938, v. 1, p. 312).

The variable nature of the flow of the Rio Grande in the years prior to construction of Elephant Butte Dam caused much crop loss and induced a number of farmers to install irrigation wells in order to have a dependable water supply. Slichter (1905, p. 51-73) gave data on 10 irrigation wells in 1904 in the vicinity of Las

Cruces and Mesilla Park and 3 near Berino. The construction of the wells and the pumping equipment ranged from poor to good. All pumps but 1 were of the horizontal centrifugal type, set in open pits about at the water level. The diameters of the wells ranged from 5 5/8 inches to 12 inches, only 2 being more than 10 inches. The wells ranged from 48 to 75 feet in depth and had from 8 to 18 feet of strainer in the bottoms. The measured discharge of the wells ranged from 131 to 1,000 gpm with specific capacities of about 6 to 88 gpm per foot of drawdown. The first irrigation wells were the 2 of the Agricultural College at Mesilla Park (Slichter, 1905, p. 22). These 2 wells were each 48 feet in depth, of good construction, and equipped with good motors and pumps. The 6-inch well produced 800 gpm and the 12-inch well 1,000 gpm, the latter with a specific capacity of 88 gpm per foot of drawdown.

Lee (1907, p. 41-47) gave data on additional wells in the Mesilla Valley. Nine of these wells, ranging in depth from 51 to 197 feet, were of moderate to large capacity and discharged from 130 to 1,500 gpm.

A 12-inch well of the Agricultural College located on the Horticultural farm near Mesilla Park was drilled in 1905 to 62 feet and an 18 foot strainer was placed in the bottom. The pump discharged 1,000 gallons a minute. This well eventually filled with sand and was replaced by a new well, Horticulture well 2, about 75 feet to the southwest. This newer well was not successful as the maximum discharge was only about 250 gpm. In 1935 another well, Horticulture well 3, was drilled about 2 feet from the original location of Horticulture well 1. Well 3 was successful and discharged about 1,100 gpm (New Mexico Agr. Exper. Sta. 1934-35, p. 53-38). However, this well also gradually filled with sand until by November 1946 the sustained discharge was only about 250 gpm.

The 6-inch well of the Agricultural College, described above, known as Irrigation Department Well 1, was replaced about 1915 by a new well, Irrigation Department Well 2, about 40 feet west of well 1. Well 2, 12 inches in diameter below the pit and only 43 feet deep, discharged 1,400 gpm. Well 2 also filled with sand and was in turn replaced in 1935 by Irrigation Department Well 3, about 35 feet north of well 1. Well 3 initially was a poor well but after about 2 weeks of development of the well its discharge increased to a maximum of 1,625 gpm. This well is still in use at the present time, and a pumping test of it is described in another section of this report.

An irrigation well of the old Shalam Colony is described by Lee (1907, p. 45). This well consisted of a circular pit 18 feet in diameter to a depth of 30 feet, with the sides and bottom cemented. Five wells were drilled in the bottom of the pit, of which 3 were 6 inches in diameter and drilled to a depth of 90 feet, 1 was 12 inches in diameter, drilled to 90 feet, and the other was 6 inches in diameter, drilled to 197 feet. The pump discharged 1,500 gpm with a drawdown in the pit of 18 feet. This well, now owned by Rudolf Garcia, is still in existence. In November 1947 a turbine pump was installed and reportedly pumped 1,000 gpm with a drawdown of 16 feet. The well is in the northwest corner of the NE1/4 sec. 21, T. 22 S., R. 1 E., about 400 feet west of U. S. Highway 85.

A well, known as the Mesa Pumping Plant, was drilled about 1908 at the Agricultural College, on the low bench on the east side of the river. A concrete-lined circular pit was dug to water at 70 feet and a 12-inch hole sunk an additional 31 feet, which penetrated fine gravel for 12 feet and below this very fine sand. A 20-foot strainer was inserted into the bottom of the well. The discharge of the well was 354 gpm with an estimated specific capacity of about 16 gpm per foot of drawdown, as computed from the water horsepower reported (Fleming and Stoneking, 1909, p. 31. 32). This well is still in existence and because of its relatively poor water, as compared to that from the newer college wells, is used primarily for filling the swimming pool at the college.

Many of these older wells were of small capacity. However, the type of pumps and motors, the comparatively shallow depths, and the small length of strainer in many of the wells suggest that the small discharges were due principally to the well construction and equipment rather than to formations with low permeability. Many of the wells when pumped tended to fill with running sand.

PRESENT DEVELOPMENT

DOMESTIC SUPPLIES

The principal use of ground water in the Rincon and Mesilla Valleys at the present is for domestic purposes. The entire population of the area depends upon ground water for domestic supply, nearly all of which is obtained from wells drilled in the valley fill.

The city of Las Cruces obtains water for the municipal supply from 6 wells drilled upon the edge of the mesa east of the city. The production of these wells, when pumped individually, ranges from about 200 to about 300 gpm per well. All 6 wells are located close to a 2,885,000-gallon reservoir. Because of the close spacing of the wells, which results in mutual interference of the pumping effects, the total output with all 6 pumps operating is estimated to be not more than 1,200 gpm or 1,728,000 gpd. Before the addition of the last 2 wells in 1947, the consumption of water during the summer was such that the 4 wells were operated continuously during the day and 3 during the night. The maximum daily consumption in 1946 and 1947 is therefore estimated to have been about 1,000,000 gallons, and the annual pumpage about 300,000,000 gallons.

The village of Hatch obtains its water supply from a group of springs about 8 miles southwest of the town, in Spring Canyon Arroyo. The town has a well, for emergency use, drilled near the river levee. The maximum water consumption of the town is reported to be about 45,000 gallons a day, with an average of about 500,000 gallons a month.

Mesilla Park is furnished water by a privately-owned system consisting of 4 wells. The daily consumption is estimated by Mr. Archer, the owner, as about 10,000 gallons.

The New Mexico College of Agriculture and Mechanic Arts at State College, east of Mesilla Park, obtains its water supply from two wells drilled at the college above the level of the valley floor. Another well is used for emergencies and for filling the swimming pool. A new well for domestic use, drilled in 1947, is not at present equipped with a pump.

Residents of Rincon are furnished water by the Santa Fe Railway, obtained from a well drilled on the south side of Rincon Arroyo, about 3 miles northeast of Rincon. The discharge of the well is estimated as 170 gpm on the basis of the rate of filling of the water tank at Rincon. The daily use of water is about 67,000 gallons by the railroad and about 5,000 gallons by the town.

Residents of the valleys not served by one of the above domestic-supply systems generally obtain their domestic water from individual wells at their homes. These private wells range from shallow dug or driven wells equipped with buckets or pitcher pumps to jetted wells more than 300 feet in depth. Most of the jetted wells have casing 3 inches in diameter, with no perforations and draw their water from the lower end of the casing, which usually is set at the top of a gravel or coarse sand deposit immediately below a clay lens. The deeper wells generally have been drilled to seek water of a better quality than that near the surface. Some wells that were intended to be drilled to only shallow depths for good water were reportedly drilled deeper before a coarse sand or gravel deposit was encountered below a suitable clay lens. If wells of this type end in fine sand, the sand may partly fill the casing when the well is pumped, resulting in reduced yield. Many of the domestic wells are equipped with small automatic pressure pumps.

IRRIGATION SUPPLIES

Development of irrigation wells was quite rapid in 1947 and 1948 as a result of the anticipated shortage of surface water. At the end of 1946 about 11 irrigation wells were in operation in the Rincon and Mesilla Valleys, 5 of which had been in operation for a number of years. By the end of 1947 about 45 additional wells has been drilled for irrigation and other wells were in the process of being drilled. However, not all the new wells were equipped with pumps and a few, undoubtedly, will prove unsuccessful. About 70 wells drilled in the Mesilla and Rincon Valleys by February 1948 apparently had or would have sufficient water for irrigation.

Twelve of the irrigation wells drilled and equipped with pumps by the end of 1947 are on the side slopes of the valleys, above the level of the valley floor and present canal system. Eleven of these wells of which 9 were drilled in 1946 and 1947, are in the Rincon Valley, and the other 2 are in Mesilla Valley.

Owing to the anticipated shortage of surface water in 1948, normal winter releases of surface water were suspended from the end of the growing season in 1947 to the beginning of the growing season in 1948. No surface water was to be delivered in 1948 to lands classified as suspended, and only 2 acre-feet per acre was to be allowed initially on the classified lands. Because of these water-conservation measures, many irrigation wells were drilled to serve tracts of land devoted to truck crops that require winter irrigation and to tracts classified as suspended. However, irrigation wells have been drilled also on SCC classified lands (p. 18) as a crop-insurance measure in the event of a shortage of surface water.

PERFORMANCE OF EXISTING WELLS

The discharge of a well, other things being equal, is dependent upon the size and condition of the pump and its speed, which in turn is dependent upon the amount of power available. A pump discharging only a few gallons a minute does not in itself indicate whether the well is a poor well or a good well. In order to make a comparison between wells the specific capacities are usually given, expressed in gallons a minute per foot of drawdown. For a particular well this value is generally regarded as nearly constant for reasonable values of drawdown. For cased wells the specific capacity depends to some extent upon the perforations in the casing. If they become plugged or are insufficient in total area a low specific capacity may be indicated even though the aquifer is highly permeable.

The ultimate yield of and drawdown of water level in most of the wells can be inferred from the hydrologic characteristics of the aquifer, the coefficient of transmissibility, and the specific yield. Based on results of pumping tests and correlation of drain flow with ground-water gradients, the average coefficient of transmissibility for the Rincon and Mesilla Valleys is estimated to be 75,000 gpd per foot. In other areas of New Mexico where irrigation from wells is done successfully the average coefficient of transmissibility ranges from about 50,000 to about 100,000. In addition to the favorable coefficient of transmissibility, the water is quite shallow under the valley floor of the Rincon and Mesilla Valleys as compared with depths to water of 30 to more than 100 feet in other areas in New Mexico where ground water is pumped.

Reliable information on some of the present irrigation wells in the Rincon and Mesilla Valleys is lacking, particularly of those that had not been equipped with pumps by the time field work on this investigation had ended. Of 9 wells in the Rincon Valley floor equipped with pumps, the discharges, either measured or reported, range from 250 to 1,000 gpm. The specific capacities of 5 of the wells range from 57 to 96 and average about 70 gpm per foot of drawdown, values which indicate good irrigation wells.

In addition to the irrigation wells in the valley floor in the Rincon Valley, about 15 wells have been drilled on the alluvial fans of the arroyos west of the valley, 12 of which are equipped with pumps. The discharges of 11 of these wells, either measured or reported, range from 250 to 850 gpm and the specific capacities of 10 of them range from 11 to 100 and average about 50 gpm per foot of drawdown.

Two wells above the valley floor in the Rincon Valley, drilled by Mr. Osborn for irrigation, were unsuccessful. Well 16.5.25.341, in the alluvial fan of Percha Creek, produced only about 125 gpm with a drawdown almost to the bottom of the well. Well 17.5.10.442, on top of the bluff of the Santa Fe formation overlooking Montoya Arroyo, obtained only a small quantity of water, which was under sufficient pressure to rise to about 30 feet above the adjacent arroyo bed.

In the Mesilla Valley, by the end of 1947, there were about 24 irrigation wells on the valley floor and 2 on the alluvial slopes above the valley floor that were equipped with pumps. Also completed were 4 wells on the valley floor and 3 above the valley floor that were drilled for irrigation but not equipped with pumps. In addition, there were other wells in the process of being drilled. Only 4 of these 33 wells were in existence prior to 1947, and 1 of the new wells, on the horticultural farm of the State College, is a replacement of a previous irrigation well.

As most of the irrigation wells in the Mesilla Valley are quite recent, their performance characteristics are not generally known. This is especially true of the drawdown of the water level when the wells are being pumped. The reported discharge from 16 of the wells on the valley floor range from about 600 to more than 2,000 gpm, with reported specific capacities for 8 of the wells ranging from less than 20 to about 60 gpm per foot of drawdown. The discharge measured for 2 wells were 1,100 and 1,270 gpm, with specific capacities of about 25 and 97.

As tractors furnish power for many of the wells at the present time, it is probable that the pumps are not being operated at capacity. Continued use of the wells generally results in an increased capacity as the fine sand from the formation around the well is removed. Running sand tends to fill the wells and causes the ground surface to cave. In order to keep the sand from filling the wells, constant pumping of the wells during development should be continued as long as the water contains sand. In addition to this trouble with sand, the inadequate perforations in some wells become plugged with fine gravel and sand.

The T. L. Simpson irrigation well furnishes an example of the effect of sand running into a well and of inadequate or clogged perforations. The well was drilled to a depth of 80 feet and the lower 20 feet of the casing was perforated with a Mill's knife. Large gravel was penetrated from 55 to 80 feet. Initially the pump discharged a maximum of about 800 gpm when the water level was drawn to the bottom of the pump suction pipe at about 60 feet. After cleaning out 10 feet of sand and gravel that had come into the well and reperforating the casing, the discharge of the pump was increased to 1,200 gpm with a smaller drawdown.

In order to reduce caving of the ground surface around the well, many wells are not drilled larger in diameter than the casing. The annular space between the hole and the casing is then filled with gravel, which fills the cavity that is formed by removal of the sand when the well is pumped. So far as the long-term yield of the well is concerned, gravel packing does not increase the discharge of the well. The ultimate production of a well is dependent upon the permeability of the formation surrounding the well at a distance and cannot be changed by the addition of the gravel.

Packing together of the gravel and sand and filling of the perforations by the mixed gravel and sand may cause the permeability around the well to be lower than that of the sand alone and may actually decrease the discharge of the well at a given drawdown. Wells that can be developed by removal of the sand without caving of the ground surface and without the gravel will be as productive, if not more so, than if gravel is used. If a large amount of gravel is used, if the perforations of the casing remain open, and if the porosity of the gravel is not reduced by the sand, the gravel serves to enlarge the effective diameter of the well, decreasing friction and consequently increasing its specific capacity. Gravel of a single size has a high porosity and is to be preferred to gravel of mixed sizes, which packs tighter and results in a lower porosity.

Performances of the present irrigation wells indicate that successful wells can be obtained nearly everywhere on the valley floor of the Rincon and Mesilla Valleys, provided that proper drilling and development methods are used to care for the large amounts of fine running sand. Reports of drillers suggest that more fine sand may be found in the lower part of the Mesilla Valley than in the remainder of the valley. Wells in the Selden Canyon area of the Rincon Valley and in the extreme upper part of the Mesilla Valley will be near mountain masses which delimit the sediments supplying water to the wells and result in comparatively large drawdowns after a period of time.

Irrigation wells on the alluvial slopes above the valley floor generally will be successful, although the capacity of most such wells will be smaller than that of wells in the Quaternary alluvial fill of the valley. Some attempts to obtain wells on the alluvial slopes will fail because of the local predominance of clay and fine sand mixed. Some difference is to be expected in the permeability of the undisturbed Santa Fe formation that forms the bluff along the valley and of the alluvial fans, slopes, and arroyo deposits formed from the erosion of the Santa Fe formation. However, no definite difference in the yield of wells drilled in these deposits has been noticed, good and poor wells having been completed in both the undisturbed and the reworked deposits.

FUTURE DEVELOPMENT

The extent to which irrigation from wells will be practiced in the future is dependent in large measure on whether surface-water supplies for the project lands continue to be insufficient. It is also dependent on whether farm prices conductive to development of new lands continue in effect. The present average farm cash return is at an all-time high, with indications that favorable conditions will continue for some time.

Even if sufficient surface water becomes available for the project lands, including those classified as suspended, the incentive for development of irrigation wells on high lands bordering the valley will remain. The initial cost of such land is comparatively small and its economic development probably can compete favorably with that of the project lands.

The acreage of land that can be irrigated by surface water in the Rincon and Mesilla Valleys has reached the maximum possible, being limited primarily by the amount of water available. In general less than one-third of the suspended land has been given water each year. It is supposed that in a dry year this part of the suspended land, about 4,600 acres in 1946, would not be allowed to have water. Therefore in such a dry year, when even land having a full water right might not have a full supply of water, there would be a tendency for farmers who have large tracts of suspended land to install pumps. This might also occur where an acreage of suspended land is being farmed in conjunction with land having a water right. A small tract of suspended land probably would not be irrigated in a dry year as in general it would not be economically feasible to install an irrigation well and pump on a tract of less than 20 acres. If there happened to be a few such small tracts adjoining each other it is possible that the owners might put down a cooperative well.

In 1946 there were 135 tracts of 20 acres or more of suspended land of all classifications in the Rincon and Mesilla Valleys, including the Texas portion of Mesilla Valley, with a total area of 5,822 acres, as given in the following table. This might be an indication of the maximum area of suspended land upon which wells would be drilled for irrigation. This area of 5,822 acres is slightly more than the 4,606 acres of suspended land reportedly irrigated with surface water in 1946, although not necessarily comprising the same tracts of land. The suspended land irrigated in 1946 was mainly land classified as seeped (waterlogged).

In addition to suspended land in the valleys that might be irrigated with ground water, a large part of which is now irrigated by surface water, new land susceptible to ground-water irrigation is available that is not now being farmed. This additional land is not now being farmed. This additional land is not within the area served by canals and some of it is located outside the boundaries of the Elephant Butte Irrigation District. The results of a reconnaissance survey by G. R. Chenot include the estimated maximum acreages of land that might be susceptible to irrigation by water from wells.

Tracts (20 acres or more) of land classified as suspended and irrigated suspended land in Rincon and Mesilla Valleys (including Texas portion), 1946

[From records of U. S. Bureau of Reclamation]

	Classification																Suspended land, irrigated (acres)
	High		Sandy		Overflow		Seeped		Poor soil		Rough		Isolated		Total		
	No. of tracts	Acres	No. of tracts	Acres	No. of tracts	Acres	No. of tracts	Acres	No. of tracts	Acres	No. of tracts	Acres	No. of tracts	Acres	No. of tracts	Acres	
Rincon Valley....	1	91	2	61	13	743	14	925	1	24	3	77	14	620	48	2,541	1,834
Mesilla Valley...	2	83	6	214	12	379	48	1,914	13	436	3	92	3	163	87	3,281	2,772
Total..........	3	174	8	275	25	1,122	62	2,839	14	460	6	169	17	783	135	5,822	4,606

The acreages, given in the following table, have been divided into areas inside and outside the boundary of the Elephant Butte Irrigation District.

Estimated acreage of new land inside and outside the boundaries of the Elephant Butte Irrigation District that might be susceptible to irrigation by ground water

	Inside (acres)	Outside (acres)	Total (acres)
Rincon Valley	900	4,700	5,600
Mesilla Valley (N. Mex.)	2,000	4,700	6,700
Mesilla Valley (Tex.)	....	900	900
Total	2,900	10,300	13,200

The area in the Rincon Valley susceptible to ground-water irrigation was determined by sketching, in the field, the lands that were fairly smooth, not cut by large arroyos, not too rocky, and with gentle slopes. The valley sheets of the Bureau of Reclamation, to the scale of 1 inch to 2,000 feet, were used as a base for sketching. None of these lands were on the higher mesa land; practically all were in arroyo deposits.

The area of land in the Mesilla Valley susceptible to ground-water irrigation was sketched upon the standard U. S. Geological Survey topographic maps, which had a scale of 1:62,500, about 1 inch to the mile, with a contour interval of 25 feet. The lands were limited to those having an altitude of not more than 100 feet above the river. Lands included were those with gentle slopes that were fairly smooth, not too rocky, and not cut by large arroyos. Most of the favorable land was located on the east side of the river on the low benches and below the upper mesa surface.

These acreages of land suitable for ground-water irrigation are gross or maximum figures and would be reduced by the areas needed for roads and other improvements, areas having land not suitable for farming, and areas in which successful wells could not be obtained. Some areas of rough lands or lands having a large slope probably could be leveled and terraced with the large earth-moving machinery now available.

It seems probable that about 15,000 acres of suspended and new land might eventually be irrigated with ground water, provided that conditions remain favorable for such development. If such development occurred, the minimum amount of water consumed annually on these lands would be about 38,000 acre-feet, on the basis of 2.5 acre-feet per acre. As a large part of these lands is on the higher ground along the edges of the valley, only a part of this water at the outset would be diverted from the drains or the river. However, as all the ground water in the valleys and mesas is connected with and contributes to the flow of the drains, any pumping must eventually mean a decrease in drain flow, in the long run equal to the amount that had been pumped, less any return of irrigation water and any small amount saved by reduction of evapotranspiration losses.

PUMPING OF GROUND WATER

GENERAL CONDITIONS

Pumping a well results at first in lowering the water level in the well and in the aquifer immediately surrounding the well, forming the so-called cone of depression in the water table. The rate of lowering of the water level is initially rapid but gradually slackens as time goes on. The drawdown at any particular time is dependent upon the rate and length of pumping and the hydrologic characteristics of the aquifer. In time, lowering of the water level occurs at greater and greater distances from the pumped well, the area affected continually expanding but at a diminishing rate. Stability of the cone of depression is not attained, until an area of rejected recharge or an area of ground-water discharge is reached.

In many localities, areas of rejected recharge and ground-water discharge either do not exist or are at such great distances that water pumped must be taken from storage for years, with a consequent continual lowering of the water table. All water pumped from wells is balanced by a loss of water somewhere in the ground-water system, commonly from the amount stored underground or from the amount seeping out of the aquifer; often in humid regions, but less commonly in arid regions, the ground-water pumpage is compensated for by a reduction in the discharge to streams in recharge areas (rejected recharge) that occurs because the aquifer is full.

Areas of ground-water discharge in the Rincon and Mesilla Valleys are the drainage ditches, where lowering of the water table would result in a decrease in the accretion of the drains, and the relatively small areas of waterlogged (seeped) land where a lowering of the water table would decrease the evaporation and transpiration of the ground water. Also, in sections of the river where the river level is below the level of the ground water, a lowering of the water table would result in a decrease of the accretion to the river, such as would occur with a drain.

Areas of rejected recharge are sections of the river where the water level in the river is above and in direct contact with the ground water. A lowering of the water table in such areas would induce a larger amount of water to seep from the river.

The increased seepage from the river to the aquifer and the decreased drain flow and return seepage to the river that would result from the pumping would not make more water available to the project as a whole but, instead, would divert to the pumps water that would otherwise be available as surface supply lower down the valley. However, any water saved by pumping that is now lost by evapotranspiration in the waterlogged areas would result in an actual increase in water supply for beneficial use in the project. Unfortunately, the amount of water saved from transpiration would be small, as only 5,135 acres within the boundaries of the Elephant Butte Irrigation District in the Rincon and Mesilla Valleys in 1946 was classified as seeped. Part of this seeped land is already farmed, and part of it is in areas distant from likely sites for wells, or near the river or outlets of the drains, where a substantial lowering of the water table would be unlikely. Transpiration by plants in rights-of-way along the banks of canals, laterals, drains, or the river could not be reduced significantly by a lowering of the water table.

Additional suspended land classified as rough, sandhill, alkali, poor-soil, isolated, and overflow—totaling 5,483 acres—may have sufficient native vegetation transpiring water, so that a lowering of the water table would save water. However, of the 10,985 acres of land classified as suspended, 4,606 acres (mainly that classified as seeped), was farmed in 1946.

An indication as to the area of land from which water is transpired to such an extent that some might be saved by a lowering of the water table can be gained from the tables on pages 19 and 20. Areas in which a lowering of the water table would not result in a reduction of transpiration, such as rights-of-way, cities, and irrigated land, or areas in which a lowering of the water table is not possible, such as the river bed between levees and river and canal surfaces, are listed in the following classification. The area for cities had been increased from 1,633 acres, shown for 1936, to an estimated 2,000 acres to take into account the growth of the residential areas.

Classification of type of area

	Acres	Acres
Cities (1947 estimate)	2,000	
Irrigated (1947)	101,700	
Rights-of-way (1947)	8,300	
River and canal surfaces (1936)	6,700	
River bed, between levees (1947)	11,200	
Total classified area		129,900
Other lands (water consuming?)		8,400
Total valley area		138,300

The difference between the total valley area and the areas named, that is, 8,400 acres, is presumably the maximum area under which a lowering of the water table might effect a reduction in transpiration losses, provided that this area had native vegetation dependent upon shallow ground water. There may be some duplication in the areas of "river and canal surfaces" and "river bed between levees," but as some additional right-of-way areas have not been determined the inconsistencies may be balanced. As not all the area of 8,400 acres would be located where the effects of pumping would be appreciable and as not all the transpiration from favorably located areas could be stopped, probably a few thousand acre-feet of ground water in the areas of transpiration could be salvaged by lowering the water table.

The effect of continuous pumping upon the water table is shown in the vicinity of Las Cruces by the displacement of the water-table contours around the city wells, the college wells, and to some extent around the Country Club well. (See pl. 1.) These wells are located on the higher lands east of the valley, in T. 23 S., R. 2 E. The Country Club well is the southeasternmost well shown in sec. 6, the 6 city wells are in a small group in secs. 8 and 17, and the 2 used college wells plus 2 unused new wells are in a small cluster in sec. 29. The cone of depression shown by the contours of the water table around the city wells is quite apparent and indicates a lowering of the water table of at least 10 feet and possibly as much as 15 feet from the probable original level given by projected contours of the water table over the area affected. Small cones of depression are indicated around the Country Club and college wells, with a lowering of the water table of possibly 5 feet.

EFFECT OF PUMPING UPON FLOW OF DRAINS

The effect of pumping a well upon the flow of a drain or a river that is in direct connection with the water table can be evaluated theoretically with the aid of the following formula developed by Theis (1941, p. 736).

$$P = (2/\pi) \int_0^{\pi/2} e^{-K \sec^2 u} du$$

in which

P = percentage of the pumped water taken from a river or a drain.

$K = 1.87a^2 S/Tt.$

a = distance from well to river or drain, in feet.

S = specific yield.

T = coefficient of transmissibility.

t = time since well began pumping, in days.

In the development of this equation a number of simplifying assumptions were made. The aquifer is considered to be homogeneous and isotropic. The coefficient of transmissibility of the aquifer is considered constant, which for thick alluvial aquifers may be approximately true. The course of the river or drain is idealized as a straight line. The ground water is assumed to be in free communication with the stream or drain; that is, the stream bed is not so heavily silted as to offer appreciably more resistance to the movement of ground water than would normally occur in the aquifer. This assumption may not be true for certain sections of a river but would be true in the case of open drains. It is also assumed that the stream or drain maintains a flow past the pumped area and that the level of the water in the stream or drain is not changed significantly because of the pumping.

It can be shown from the equation (Theis, 1941, p. 736) that more than half the effect upon the stream or drain resulting from the pumping of a well occurs between a point upstream from the well at a distance equal to that of the well from the stream and a point downstream the same distance. At greater distances up or down the stream or drain the effects of the pump rapidly diminish. Therefore, if the stream or drain retains an approximately straight line past the pump for distances of more than twice that of the pump from the stream or drain, the equation will give usable results.

The results will be affected significantly if the lowering of the water level from pumping reduces the amount of transpiration from the aquifer or if the effects of the pumping reach the limits of the aquifer. This last condition will occur in the Rincon Valley from Hatch northward, where the valley is flanked on the east by the Caballo Mountains, and in the Selden Canyon area where the aquifer is shallow and is flanked on the east and west by mountain masses of the Sierra de las Uvas. The Mesilla Valley is flanked, in general, by sediments having a lower coefficient of transmissibility than that of the valley deposits. When the effect of the pumping reaches the limits of an aquifer or reaches an aquifer where the coefficient of transmissibility is less than in the aquifer being pumped, the rate of decline of the water level caused by the pumping will increase.

The theoretical effect of a pumping well upon the flow of the river or a drain in the Rincon and Mesilla Valleys is shown on figure 15, which has been computed from the formula by using the average coefficient of transmissibility of 75,000 and a specific yield of 25 percent for the Rincon and Mesilla Valleys. The percentage of the pumped water diverted by a single well from the flow of a stream or drain is obtained from the graph by the value of the

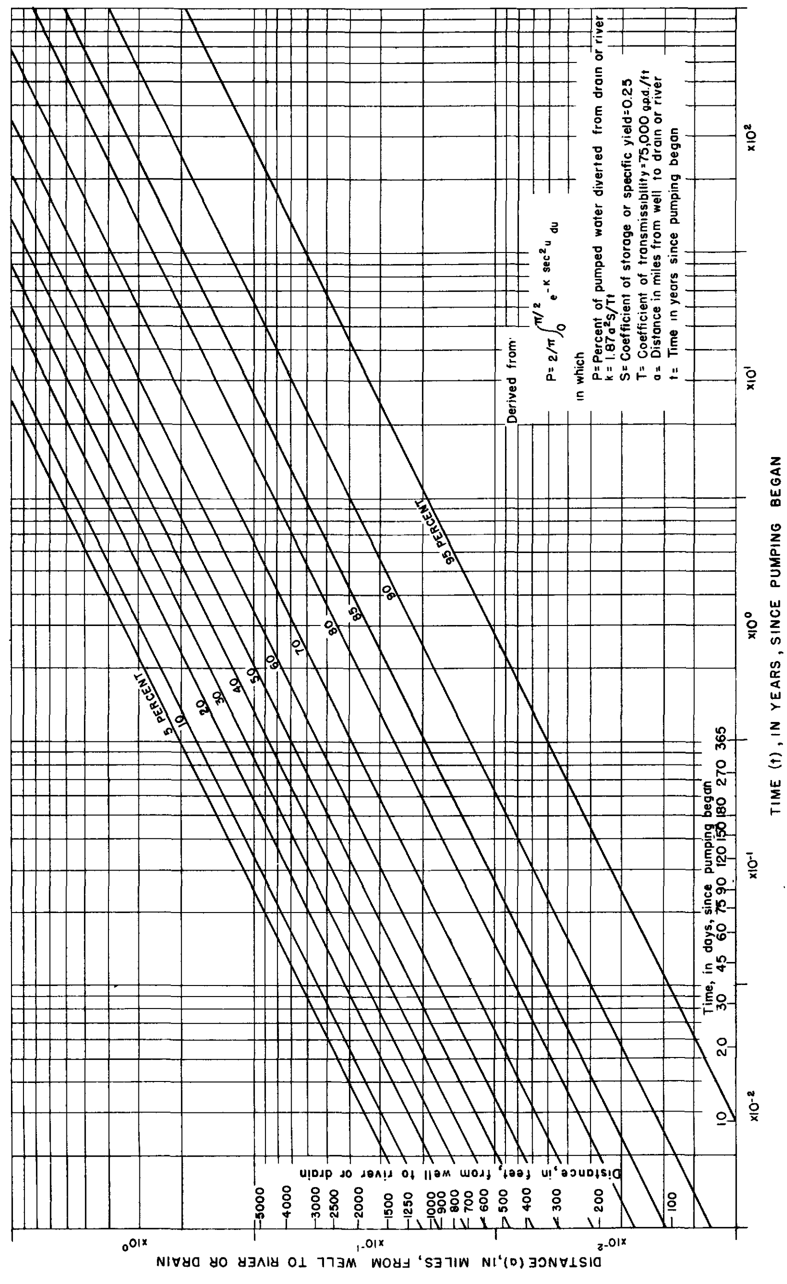

Figure 15. —Percentage of pumped water diverted from a drain or the river by a pumped well in Rincon or Mesilla Valleys.

sloping line determined by the intersection of a horizontal line at the distance of the well from the stream or a drain and a vertical line at the time since pumping started. The residual effect of a pumped well after pumping stops can be determined by the difference in effect caused by a well pumping continuously from the time of start to the time in question and a recharge well pumping from the time of actual stop to the time in question.

This diagram shows that if a well in the Rincon or Mesilla Valleys were located a quarter of a mile from a drain the flow of the drain would be reduced after 3 months of continuous pumping by 63 percent of the pumping rate, after 6 months by 73 percent of the pumping rate, and after 1 year by 81 percent of the pumping rate. After 6 months of continuous pumping the flow of a drain would be reduced by 88 percent of the pumping rate for a well located an eighth of a mile from the drain, 73 percent for a well located a quarter of a mile from the drain, 50 percent by a well located half a mile from a drain, and 18 percent by a well located 1 mile from a drain. Within 12 days 50 percent of the water pumped by a well located an eighth of a mile from a drain would be diverted from the drain, but it would take about 2 years for a well located 1 mile from a drain to have the same effect. If a well located a quarter of a mile from a drain were pumped for 6 months and then stopped, the drain would still be losing water 1 year after the start of pumping, or its accretion would be reduced, at 8 percent of the pumping rate.

As evident from the formula and the graph, if the distance from the well to a drain is doubled the time necessary for the same effect upon the drain is four times as long; that is, for the same effect, the time varies as the square of the distance.

The effect of pumping upon the flow of a stream or a drain, in which the water is in free communication with the ground water, will be evidenced initially either by a decrease in the accretion of ground water by a gaining stream or drain, or by an increase in the rate of loss of water from a losing stream or drain. With continued pumping, in the case of a gaining drain or stream, the gradient of the water table would be reversed and the drain or stream would lose water in the section affected and finally in either case, if the pumping rate were great enough, the stream or drain would be dried in that section.

In order to dry the drains, the pumping effect per mile of drain must be at least equal to the accretion of the drain per mile. The average drainflow accretion under the present conditions of an average surface supply of water is about 0.8 cfs per mile in the late winter months, increasing to almost 2 cfs per mile in the late summer, with a maximum range from about 0.5 to 2.5 cfs per mile based upon the total lengths of the drains. Certain stretches will probably show greater or less accretion than this. Wells placed a quarter of a mile from a drain at 1-mile intervals, each pumping continuously at the rate of 3 cfs, theoretically would dry a drain in the summer under the present conditions of drain flow after about 4 months of pumping. In a year with less than the average supply of surface water, the flow of the drains would be less than normal and the amount of pumping required to dry the drains would be less.

The theoretical effect of the pumping of a well upon the flow of a drain is possibly somewhat greater than would actually occur at any particular time because of clay layers that extend under the drains, which might introduce a lag in the effects of pumping from wells that extend below the clay layers.

If a well were located between drains or between a drain and the river, the total depletion of their flow after any given period of pumping from the well would be greater than if only one drain were involved. As the ultimate effect is the same, locating a well between drains only speeds up the effect of the pumping. This accelerated effect of the pumping probably would offset the possible lag caused by the stratification of the aquifer.

The maximum practical distance that a well can be located from a drain or the river in the Rincon and Mesilla Valleys is about a mile because of the narrowness of the valleys and the numerous drains. At the northern end of the Rincon Valley in the vicinity of Arrey, where there are no drains, a well on the valley floor could be as far as a mile from the river. Also, near Salem the maximum distance from a drain that a well on the valley floor could be located is about a mile. In the remainder of the Rincon Valley the maximum distance from either the river or a drain is less than a mile, in general being closer to half a mile, and for a large number of wells the average distance probably would be between a quarter and half a mile. In some areas it would be necessary to locate a well near a canal in order to be at a maximum distance from the river or a drain.

In the Mesilla Valley, where drains are more numerous than in the Rincon Valley, practically the only area where wells on the valley floor could be more than a mile from the river or a drain is in Las Cruces. The maze of drains in the rest of the valley precludes locating a well much more than half a mile from the river or a drain and then the well might be near a canal. Also, in most of the valley a well would be situated between two drains or a drain and the river, which would increase the total effect of pumping at any particular time over that upon one drain. For a number of wells the average distance to the river or a drain probably would be between a quarter and half a mile, and many of the wells would be between two drains or between a drain and the river.

As the flow of the drains is derived principally from return seepage from irrigated lands and from canals and as interception of this seepage by a well results in a decrease in flow of the drains such interception does not reduce the ultimate effect of the pumping upon the flow of the drain.

SUPPLEMENTAL PUMPING OF GROUND WATER IN A DROUGHT PERIOD

Under the present conditions in the Rincon and Mesilla Valleys the surface and ground waters are in approximate equilibrium. The surface water is diverted throughout the year to the canals and irrigated land and a certain percentage that is not lost by evaporation and transpiration seeps underground and returns to the river directly or by drain flow for reuse in the next lower irrigation division. The drain flow, as stated before, is composed almost entirely of return diversions and seepage of river water but it contains a small amount of ground-water flow from the side mesas. The drain flow is not waste water insofar as the next lower irrigation unit is concerned but instead is counted upon as a part of the water supply of the project. Thus, no water is wasted in the project except by transpiration and evaporation—the total amount of which is increased if water is used carelessly—and for the small quantity that bypasses the lower unit, especially during the winter.

Pumping of ground water for supplemental use does not represent an additional supply or new source of water but rather a change in in method, time and place of diversion of available supplies.

The pumping effect of one well upon a drain has been discussed in another paragraph. The remaining water pumped that is not diverted from the drains or the river or saved from evapotranspiration at any particular time is taken from storage. As seen from the graph, figure 15, the percentage of water taken from storage in the case of a single well pumping for 6 months at a distance of a quarter of a mile from a drain is only about 27 percent. Thus on a short-term basis of 1 year, only about a quarter of the water pumped is taken from storage and represents water not otherwise available during that year.

Thus, on a year-to-year basis, the net gain of water to the district is that quantity of water pumped in excess of the decrease in normal drain flow caused by the pumping. This net gain of water is water taken mainly from storage, that is, borrowed from the ground-water supply. This borrowed water must be replaced in future years if the flow of the drains is to return to normal.

If in future years no excess surface water is available to the project to raise the ground-water level to the nonpumping stage, then pumping must be continued, even in a year of normal water supply, unless the pumped water is used more efficiently than surface water, in which case the total amount needed would be less and the debt to ground-water storage could gradually be reduced.

The economy of a supplemental pumping project in the Elephant Butte Irrigation District depends upon the quantity of water that must be pumped. This in turn depends upon how the gravity water in the Rio Grande project is distributed to the various valleys, what economies could be effected in its distribution, and what salvage of water would occur by reason of the lowered water table in a dry year. The distribution of surface water might be in proportion to the average diversions, or to the average river depletions. It might be assumed that pumping would be done in the El Paso district also, which would save some water that would otherwise drain from the land, and thus provide more water for the project; or it might be assumed that the El Paso district would not install pumps also, in which case the Elephant Butte district might be regarded as having an obligation not to interfere with the deliveries of water to the lower district. Some water would be saved from evaporation by drying of the drains and by lowering of the water table in waterlogged areas.

For the purpose of this study it is assumed that direct canal waste would be largely eliminated throughout the project and that the Elephant Butte district has no obligation to the lower district to continue this direct loss. It is assumed also that an obligation does exist to continue to deliver the average proportionate drain flow, which is taken to be 40 percent of the gross diversions.

As stated on page 52, in a hypothetical year in which the surface supply of water available for diversions is only half the average, it is believed that 2.28 feet of water could be delivered to the farms, or about 1 foot less than that needed for successful irrigation of the crops. If the additional foot of water were supplied by pumping ground water into the canals, some loss of the pumped water would occur, owing to waste and to seepage from the canals. Owing to closer control of the pumps and to the shorter distance that the pumped water would travel in the canals as compared with surface water, a wastage of 3 percent and a seepage loss of 17 percent of the pumped water may be assumed. This combined loss of about 20 percent is compared with a probable minimum of 30 percent for gravity water. Every additional acre-foot of pumped water delivered to the farms, therefore, would necessitate pumping about 1.25 acre-feet.

However, pumping of wells would diminish the drain flow. This decrease in drain flow presumably would necessitate a corresponding decrease in the allowable diversions for the Elephant Butte Irrigation District.

The narrowness of the valleys and the large number of drains preclude locating pumps very far from either the drains or the river. If a large number of pumps were installed, as would be necessary for a district pumping system, the average distance from a drain would be about a quarter of a mile, and it is expected that the drains would be dried during the first summer of pumping if only a small gravity water supply were available. The amount of the drain flow in an average year is about 42 percent of the gross diversions. In a dry year, with less excess water applied to the lands, the drain flow is expected to be less, probably about 40 percent of the diversions. In an assumed dry year when only 50 percent of a normal gravity-water supply were available, 3.25 acre-feet per acre would be diverted in the Rincon and Mesilla Valleys, of which 40 percent would be returned to the system as drain flow, leaving a total diversion used within these valleys of 1.95 feet. If a pumping system were installed and the drains were dried, presumably 1.95 feet would be the justifiable diversion to these valleys. It has been assumed that, in a dry year, 3.3 acre-feet of water per acre is needed for a full crop, that 30 percent of the surface water diverted would be lost, largely by seepage from the canals, and that about 20 percent of the pumped water would be lost by seepage and waste from the canals. Therefore,

$$3.3 = 1.95 \times 0.7 + \text{pumped water} \times 0.8;$$

therefore,

$$\text{pumped water} = 2.42 \text{ acre-feet per acre.}$$

Thus, in order to make up the deficiency of 1 acre-foot per acre that would result from gravity irrigation alone in the assumed dry year, it would be necessary to pump about 2.42 acre-feet per acre. This is the minimum amount with judicious use of water. If canal wastage were higher and the water were inefficiently used on the land this amount would not be sufficient.

As there are water rights for about 88,000 acres of land in the New Mexico part of the project, the total pumpage of water would be about 213,000 acre-feet and the total surface water diverted about 172,000 acre-feet.

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The amount of water pumped from storage in the ground would be the difference between the amount actually used by the crops, assumed to be 2.5 acre-feet per acre, and the amount diverted from the river, 1.95 acre-feet per acre, plus evaporation and waste from the canal. The latter has been estimated as 3 percent of the pumped water or 0.07 acre-foot per acre and 5 percent of the gravity water or 0.10 acre-foot per acre, making the water pumped from storage 0.72 acre-foot per acre per year.

Viewed in another way, the amount of water pumped from storage would equal the difference between the total water pumped and that part of the pumped and surface water that would return to the water table. This amount from storage, all quantities being given in acre-feet per acre, would be: the total amount pumped, 2.42, less the pumped water lost by seepage from the canals, 17 percent (see p. 122) or 0.41, less the gravity water lost by seepage from the canals, 25 percent (see p. 52) of that diverted, 0.49, less the difference between the water applied to the land, 3.3, and the consumptive use 2.5, or 0.8. The amount of water pumped from storage in 1 year would therefore be 0.72 acre-foot per acre irrigated, or 63,360 acre-feet for the 88,000 acres in the Elephant Butte Irrigation District. The amount of water returned underground by seepage from the canals and from the irrigated lands would be 1.70 acre-feet per acre or 39 percent of the total diversions and pumpage of about 4.4 acre-feet per acre.

The period of drought during which supplemental pumped water might be needed is, of course, a matter of conjecture. A short period of pumping would be relatively costly. The flow of the Rio Grande at San Marcial above Elephant Butte Dam, at the head of the Rio Grande project, averaged only 697 cfs in the 5-year period 1898 to 1902, inclusive, 46 percent of the 52-year average of 1,530 cfs (International Boundary and Water Commission, 1946, p. 4). During a period of drought the lake level at Elephant Butte and Caballo Dams would be low and there would be less evaporation loss than under average conditions. This reduced evaporation loss, plus what water there was in storage at the beginning of the drought, would temper the actual decrease in flow of the Rio Grande. Without extensive study it appears, therefore, that a 5-year drought period in which only half the normal supply of water would be available for diversions is about the longest that could reasonably be expected.

If pumping were done for 5 such dry years the total pumpage from storage would be about 316,800 acre-feet, neglecting water saved from evaporation or transpiration, in waterlogged areas. This amount of ground water would have to be replaced before the flow of the drains would return to normal.

As the drains would have been dried by the pumping, the diversions to the district in a year of average surface-water supply following a period of 5 years of pumping possibly would be reduced by the amount that the drains would normally flow, or 42 percent of the diversions. The actual diversion would then be 6.5 - (0.42 x 6.5) = 3.77 feet. This amount would make 2.64 feet available for delivery to the farms, thus requiring additional pumping of ground water to make up the difference to the 3.3 feet believed necessary for delivery to the farms. The amount of ground water that would have to be pumped would be

$$3.30 = 3.77 \times 0.7 + \text{pumped water} \times 0.8;$$

therefore,

$$\text{pumped water} = 0.83 \text{ acre-feet per acre.}$$

The amount of water that would seep to the water table in this year would equal the seepage losses of pumped and surface water from the canals plus the seepage return of excess water above the consumptive use delivered to the farms, and would be

$$(0.83 \times 0.17) + (3.77 \times 0.25) + (3.30 - 2.50) = 1.88 \text{ acre-feet per acre.}$$

The payment or reduction of the ground-water debt would be the return seepage in excess of the pumpage, or 1.05 feet. The number of years required, while pumping 0.83 acre-foot per acre, to pay off the debt would be 5 x 0.72/1.05 = 3.4 years.

The available surface-water diversions without pumping in the fourth year of average surface supply, following the assumed 5 years of pumping, would be less than the average by the amount of water that would have to be bypassed to the lower district to make up for the reduction in average drain flow resulting from the remaining effects of the pumping. The amount of bypassed water, x, plus the actual drain flow, y, must be equal to the average drain return flow of 2.73 feet (0.42 x 6.5) in a year of average diversions. The actual drain return flow would be equal to 42 percent of the actual diversions reduced by the remaining ground-water debt. The remaining debt would be (5 x 0.72) - (3 x 1.05) = 0.45 foot. Therefore:

$$x + y = 2.73$$

$$\text{and } y = (6.50 - x)\,0.42 - 0.45;$$

therefore:

$$x = 0.78$$

and the actual diversion would be:

$$6.50 - 0.78 = 5.72 \text{ feet.}$$

The water schedule for the 5 years of about 50-percent average surface supply followed by 5 years of average surface-water supply is given in the following table:

Comparison of irrigation water available as diversions to the canals of the Elephant Butte Irrigation District, for 5 years of 50-percent average surface supply followed by a period of average surface supply

[Acre-feet per acre]

Year of irrigation	With supplemental pumping		Without supplemental pumping
	Pumped water	Surface water	Surface water
1	2.42	1.95	3.25
2	2.42	1.95	3.25
3	2.42	1.95	3.25
4	2.42	1.95	3.25
5	2.42	1.95	3.25
6	.83	3.77	6.50
7	.83	3.77	6.50
8	.83	3.77	6.50
9	.00	5.72	6.50
10	.00	6.50	6.50
Total	14.59	33.28	48.75

Little net water can be gained to the Rio Grande project as a whole by pumping ground water in the Elephant Butte district, and the total amount of water received by the Elephant Butte district under a pumping system is practically no more than would be obtained from surface supplies, if the customary interest of the El Paso district is preserved. The reason for this is, of course, that the drain water is used again in the project and the district has been assumed to be responsible for any decrease of the flow of the drains resulting from pumping.

The ground-water debt could be repaid by efficient use of water in 4 years of average water supply. If water were wasted, it would not be possible to repay the ground-water debt and pumping probably would have to be continued for years.

As indicated previously (p. 44), Rincon and Mesilla Valleys customarily use about 46 percent of the total reservoir releases in a year of average surface supply. In the assumed drought period of 5 years the surface water available for diversions was considered as 50 percent of the average. The average diversion to the El Paso division has been 395,400 acre-feet, and therefore in such a dry year presumably 197,700 acre-feet should be available for diversion to the El Paso Valley. The reservoir releases in a year should be equal to the sum of all diversions minus the return drain flow, disregarding any nonbeneficial evaporation and transpiration losses and any undiverted water that might bypass the El Paso Valley. As the return drain flow from the Rincon and Mesilla Valleys would be zero if extensive pumping were done, the reservoir releases would be 88,000 x 1.95 + 197,700 = 369,000 acre-feet. The depletion of reservoir releases by the Elephant Butte Irrigation District for any of the first 5 years of pumping is then 46 percent, which, disregarding canal wastes, is the same reservoir depletion as in an average year. In the sixth, seventh, and eighth years, the drains still being dry, the depletion of reservoir releases would be about 45 percent. This shows that the Rincon and Mesilla Valleys would be getting their usual share of the reservoir releases.

In the analysis it was assumed that the drains would be dry during all the first year, whereas actually they would not be dry until near the end of the first pumping season and a small amount of water might flow during the first winter. Therefore, during the first summer it is probable that a smaller amount of water would need to be pumped. Also, it has been assumed that all the ground water taken from storage would be derived from the lowering of the water table under only the irrigated area of the valley. Actually, the effects of pumping would be somewhat smaller in the valley area, as the cone of depression would extend away from the valley, under the mesas. As the irrigation water is applied to lands near the drains, it is possible that water in the drains would begin to flow in the eighth year, or earlier, even though all the ground-water debt had not been repaid. The district would benefit by this lag, which would spread the repayment of the ground-water debt over a longer period of time than was assumed. A small amount of the pumped water probably would not be taken from storage but would be salvaged from areas of transpiration by the lowering of the water level. This salvaged water would be a net gain of usable water and would reduce the calculated pumpage from storage.

Pumping of ground water in the valley by individual farmers would, of course, have the same effect upon the flow of the drains as would pumping by the Elephant Butte Irrigation District. And water pumped onto the land from ground-water storage that does not return to the ground-water body would be water lost to the project, even though a gain of water might accrue to an individual farm. It is probable that in a dry year enough farmers would install wells and pumps so that the flow of the drains would be reduced markedly or, in some sections, even be stopped entirely. If in a dry year such a reduction of normal drain flow occurred through installation of individual pumps, and if the El Paso division received its accustomed share of the reservoir water, diversions to the Elephant Butte Irrigation District would have to be reduced by a like amount. Any such reduction in diversions would work a hardship on the farmers who had not installed pumps, provided that the available surface water was distributed equally. If it were desired to maintain the delivery of the same amount of water to the farms not having pumps as they would have received had there been no pumping, then it would be necessary to reduce the delivery of water to the farms having pumps. This would be the condition during years of a shortage of surface water. Pumping by individuals during years of a normal supply is discussed in the following pages.

PUMPING OF GROUND WATER WITH A NORMAL SUPPLY OF SURFACE WATER

Pumping of ground water in a year of normal supply of surface water might be practiced by individuals upon project lands for various reasons. A farmer who has a pump would have water available at times convenient to himself. And, in years when water was rationed, even though an adequate amount would be available, he would be able to pump additional water to satisfy his requirements. However, as pumped water would be an additional cost for water, it is not expected that pumping would be prevalent on project lands in years of normal supply of gravity water.

As the production of crops requires a certain amount of water and as there would be adequate surface water available for all crops in a normal year, the use of ground water for supplemental purposes on project lands in such a year would not deplete the project water supply any more than the use of gravity water, unless excessive irrigation by ground water caused an excessive consumptive use by the crops and excessive transpiration and evaporation losses.

Pumping of ground water in a year of normal surface supply could result in some saving of water to the project if pumps were located in areas of native vegetation where a lowering of water level would reduce nonbeneficial transpiration losses.

Also, use of ground water instead of surface water for winter irrigation would result in some water savings to the project, especially if drain water were pumped. Approximately 50,000 acre-feet of water is released from storage annually from October through February for winter irrigation of a widely distributed acreage planted principally to truck crops. This acreage constitutes a small percentage of the total irrigated acreage. An unusually large part of this winter release is lost through waste, seepage, and unnecessary evaporation and transpiration, the losses per acre served being proportionately much higher than those involved in irrigation in the summer.

The pumping of drain water during the winter would utilize some water that is now allowed to bypass the project. W. F. Resch, project manager of the Bureau of Reclamation, El Paso, Tex., estimates roughly that, of the drain flow passing the end of Mesilla Valley, 40 percent of that in October, 50 percent of that in November and December, 100 percent of that in January, and 40 percent of that in February is not used in the lower El Paso Valley. These percentage estimates, combined with the drain flow given in table 5, pages 141, 142, show that possibly 34,000 acre-feet of the winter drain flow is allowed to bypass the project. However, as part of the winter drain flow is a result of the large losses from the winter releases, it is not expected that this quantity would be available for pumping from the drains. Some pumping from ground-water storage would be necessary. The quantity of water saved in winter irrigation by substituting pumping, especially from drains, for reservoir releases therefore presumably would be about 34,000 acre-feet anually, if all water bypassing the project in the winter could be stopped, plus some small saving in losses from evaporation and transpiration. As drain flow removes undesirable salts from the lands and is as necessary as removal of sewage from a city, it is presumed that not all drain flow bypassing the project throughout the year should be stopped in order to save water, but that the drain flow seemingly could be profitably stopped in the winter.

COST OF PUMPING SUPPLEMENTAL GROUND WATER

The minimum number of pumps required to deliver the 213,000 acre-feet of pumped water believed necessary for the Elephant Butte Irrigation District in a dry year is estimated to be about 148, on the assumption that each pump would discharge 1,800 gpm continuously for 6 months. Allowance should be made for periods of high demand; otherwise, with the pumps running continuously at full capacity, the farmers would have to take water on a strict rotating schedule and any breakdown in pumping equipment would result in a shortage of water. Also, it is unlikely that every well drilled would be capable of discharging 1,800 gpm. Therefore, allowing a 15-percent operational variance and 10 percent for breakdowns, and assuming a lower average discharge per well of perhaps 1,500 gpm, the number of pumps necessary is estimated to be about 220.

Rough estimates made in 1948 of the costs of installation of a well, pump, and motor; fuel and lubrication; labor and transportation; total depreciation in 5 years; interest on investment; and taxes indicate a total charge of $2,900 per pump per year during the first 5 years of operation. The charge for 220 pumps would be $638,000 a year, or $3,190,000 for the 5-year period. This is equivalent to $7.25 per acre per year for 88,000 acres or $3.00 per acre-foot of water on the basis of 2.42 acre-feet per acre per year.

Under the assumptions given previously, only 73,000 acre-feet of water per year would need to be pumped in the sixth, seventh, and eighth years. This would require 75 pumps, on the basis that 220 pumps would be needed for pumping 213,000 acre-feet per year. Assuming the pumps to be fully depreciated at the end of the first 5 years, the unit cost per pump in the sixth, seventh, and eighth years is estimated at about $1,540 per year or $346,860 for 75 pumps for 3 years. The total cost for 8 years thus would be $3,536,900.

As stated previously, a 50-percent gravity supply would suffice, with extremely careful use, to irrigate about 70 percent of the acreage. The pumping of irrigation water would result in saving all the crops on the remaining 30 percent; thus the pumping costs should be justified by that acreage. The average gross return per acre for the Rio Grande project was about $140 in 1945 and about $252 in 1946, the record year up to that time. However, the average crop return on the project from 1914 to 1946 was about $84 per acre and from 1937 to 1946 was about $120 per acre[12]. The additional gross return through ground-water irrigation in 5 dry years, on the basis of 1937-46 average crop returns, would be $15,800,000. The total cost of pumping and pumping equipment is thus approximately one-fifth of the increase in average gross crop returns and probably less than the normal net profit. The average cost per acre for 88,000 acres during the initial 5 years would be about $7.25 a year.

Intermittent operation and the probable smaller capacity of a pump on an individual farm would result in a somewhat higher unit cost of pumping than would continuous operation of large-capacity pumps by a district pumping system.

The favorable factor of cost of pumping is offset somewhat by the unfavorable factor of little net gain of water and the problem of installation and operation. Installation of 220 wells, pumps, and motors would consume some time, but possibly less than the period of shortage of surface water supply. Among the operational problems would be the distribution of the pumped water to the New Mexico lands only. About 11,000 acres of irrigated land in the Mesilla Valley is in Texas and is served by the same canal system. Also, very strict operating and irrigating schedules would have to be maintained, as only a 3-percent wastage was assumed in the estimates.

RECOMMENDED LOCATION OF WELLS

Wells producing sufficient water for irrigation can be located nearly everywhere on the floor of the Rincon and Mesilla Valleys. As a result of the variable nature of the alluvial sediments that have been deposited by the meandering Rio Grande, there will be a variation in the performance of the wells. Many wells will be filled with running sand and the perforations of some well casings will be clogged by gravel and sand. It does not appear possible to predict the location of gravel stringers in which presumably better wells would be obtained than in sand alone. The meager information available indicates that sand predominates in the lower end of the Mesilla Valley.

[12] U. S. Bureau of Reclamation, 1946, Project history: unpublished report, El Paso, Tex.

With respect to the chemical quality of the water, generally better water is obtained with depth; an exception is the lower end of the Mesilla Valley, where apparently very poor water is obtained at depth. Some shallow wells in the Selden Canyon area obtain so-called salt water, which may occur also at greater depths. As the shallow water is generally satisfactory for irrigation, however, the drilling of irrigation wells deeper than 100 feet for the better water is not justified. Many domestic wells in the Mesilla Valley obtain their comparatively good water from depths in excess of 100 feet. Deep irrigation wells would possibly disturb this availability of better water with depth by drawing in poorer water from the upper strata to the lower.

As water of comparatively good chemical quality enters the valleys as underflow from adjacent arroyos, wells located on the valley floor in line with or a short distance downstream from these arroyos may obtain better-than-average water from the valley fill.

The alluvial fill in the Selden Canyon area and in the northern end of the Mesilla Valley, near Leasburg Dam, is thin and narrow. If a large number of irrigation wells were drilled in these areas and used continuously, comparatively large drawdowns of water level would result and wells drilled near the impermeable rocks at the edges of the valleys would be relatively unproductive.

In order to draw a greater percentage of the pumped water from storage, the wells should be located as far as possible from the drains and the river. Canals that leak excessively are paralleled with drains, and the water level in the canals is without doubt above the water table. The water level in sections of canals that have only a small leakage is also above the water table. Wells drilled near canals whose water is not in direct contact with the ground water will not appreciably increase the leakage from the canals, but will divert to the pumps water that would normally be picked up by drains.

Locating irrigation wells in areas of native vegetation will lower the water table in these areas and will reduce transpiration losses and save some water for the project.

Therefore, for least effect upon the project supply and for maximum well production, it is recommended that irrigation wells on the valley floors should be located as far as possible from the drains and the river; be drilled as far as practicable from the mountain masses in Selden Canyon and the northern end of Mesilla Valley; be drilled near arroyo mouths where possible; be drilled no deeper than necessary to secure an adequate supply of water; and not be drilled in the lower end of Mesilla Valley.

RECOMMENDATIONS FOR FUTURE STUDIES

As brought out previously, water pumped by wells in the Rincon and Mesilla Valleys is not an additional or new supply but, instead, is water that would normally flow to the drains and be diverted for use in a lower part of the project. Pumping of ground water, therefore, is essentially a change in point of diversion of an existing supply. In times of normal or adequate supply of surface water to the project, pumping obtains water that would otherwise be available by gravity. In a year of surface-water shortage, pumping results in an adequate supply of water to those farmers having pumps but may reduce the amount of surface water available for diversion in the lower part of the district or project. Pumping water from wells upon new lands, either in or bordering the valleys, will result in reducing to some extent the supply of water to the project.

Because of these effects of pumping upon the water supply of the project, continuing records should be kept of the amount pumped and the location of the irrigation wells.

The initial effect of the pumping, especially in a year of inadequate surface supply, will be a decrease in the drain flow. This decrease may not be readily apparent for a small number of pumps unless accurate and frequent measurements of the drain flow are made. If 75 pumps are in operation, the decrease in drain flow may amount to approximately 10,000 acre-feet a year. If measurements of the drain flow approach an accuracy of 5 percent, the error in measurements in a year of average drain flow may amount to about 12,500 acre-feet. Thus, unless accurate and frequent measurements of drain flow are made, any decreases noted could not be definitely attributed to the effects of pumping. At present, the drainage return flow is measured only at the outlets to the river. Measurements should be made at additional points along the drains in order that any decrease in flow caused by pumping can be localized within sections of the drains.

The ground-water levels will decline as a result of pumping. However, the decline will be small so long as water continues to flow in the drains, the drains acting as sources of recharge to the cones of depression caused by the pumps. An effort should be made to continue measurements in the fifty-odd auger holes in the Mesilla Valley that have been measured for a number of years by the Bureau of Reclamation. Auger holes should be installed in the Rincon Valley at pertinent locations in order to permit observation of any effects of pumping upon the water level there. Also, measurements of water level should be made in the irrigation wells at least once a year, preferably in January or early February when the effects from the previous irrigation season are at a minimum.

Records as to the performance of each well and logs of formations penetrated would aid in interpretation of the effects of pumping.

In summary, in order to have reliable data for a future re-evaluation of the effects of pumping, if such becomes desirable, the following records should be kept: information on the irrigation wells such as, location, performance, and pumpage; measurements of water level in the irrigation wells annually and in the auger wells seasonally; and additional measurements of drain flow.

SUMMARY

1. The ground water in the valley fill originates mainly from surface water, that is, from seepage of the canals and the river, and from excess water applied to irrigated lands, but partly from ground water from the adjoining high lands, and, occasionally, from precipitation upon the valley floor.

2. The quality of the shallow ground water in the alluvium of the Rincon and Mesilla Valleys is slightly poorer than drain water but satisfactory for most irrigation requirements. The dissolved solids generally decrease with increased depth of wells except in a few areas, especially in the lower end of the Mesilla Valley and in the Selden Canyon. Comparatively good water is obtained in surrounding high lands and in arroyo beds.

3. Wells yielding sufficient water for irrigation can be developed over the major part of the valley floors of the Rincon and Mesilla Valleys, with the probable exceptions of the Selden Canyon area and the southern end of the Mesilla Valley. Sanding of wells has occurred and may occur in wells that may be drilled, and special well construction may be necessary to prevent it.

4. Irrigation wells, generally of small capacity, can be developed on the arroyos and on the low benchlands. However, many wells in these areas may not obtain sufficient quantities for irrigation.

5. Pumping of ground water will divert water from the drains and the river. The drains may practically stop flowing by the end of the first summer in a dry year if enough pumps are installed to furnish an adequate water supply for all lands.

6. If an increased portion of releases from the reservoir were made up to the lower district as compensation for the reduction in flow of the drains, caused by pumping in the Rincon and Mesilla Valleys, a corresponding reduction in the diversions to the Elephant Butte Irrigation District would be necessary.

7. As no unused ground-water recharge escapes from the project, and there is very little unused ground-water discharge, only a small amount of water can be salvaged to the Rio Grande project as a whole over a period of years by pumping in the Elephant Butte district.

8. Assuming that the El Paso division continues to get diversions in the same proportion of reservoir releases as in the past, pumping of ground water will not result in any additional water for the Elephant Butte Irrigation District on a year-to-year basis unless the amount of pumping exceeds the amount of the diverted drain flow, when this excess will come from storage.

9. On a long-term basis nearly all water removed from storage must be replaced before the flow of the drains returns to normal.

10. With a gravity water supply available for diversions of 50 percent of average, about 70 percent of the land in the Elephant Butte Irrigation District probably could be irrigated by careful use and control of gravity water alone.

11. During a year in which the normal supply of surface water is deficient by 50 percent, an additional acre-foot per acre would be needed to successfully irrigate the water-right land in New Mexico. To supply this deficit for 88,000 acres by pumping from wells would, because of distribution losses and reduction in flow of the drains caused by pumping, require pumping 213,000 acre-feet per year, assuming that the El Paso division receives its accustomed share of the reservoir water.

12. As supplemental pumpage would in effect save the crops on 30 percent of the land that could not be irrigated by surface water in a year of 50-percent gravity supply, the additional gross crop return resulting from pumping would be $15,800,000 for a 5-year period on the basis of the average annual gross crop return from 1937-46 of $120 an acre.

13. The total number of wells and pumps required in a year of 50-percent gravity supply is estimated to be about 220 and the total cost about $3,190,000 on the basis of a 5-year period and $3,536,900 for 8 years, including all charges, or approximately one-fifth of the average gross dollar benefits from crops grown.

14. Total cost per acre-foot of water pumped would be about $3.00, equal to about $7.25 per irrigated acre per year for the district.

15. Pumping of ground water on individual farms in years of deficient gravity water supply would ultimately reduce the water

supply of the Rio Grande project. If such a reduction were borne by the Elephant Butte Irrigation District, it would be necessary to reduce deliveries of surface water to farms with pumps in order to maintain the expected deliveries to farms without pumps.

16. Pumping of ground water for winter irrigation in the project could effect savings in water, as losses of winter releases are disproportionately large for the acreage irrigated.

17. About 15,000 acres of now undeveloped land and suspended land could be irrigated by ground water. Water pumped on these lands will, in a few years, reduce the water available to the existing irrigated lands by an amount equal to the consumptive use by the lands and crops irrigated.

18. As the water pumped will affect the water supply of the project, especially in years of deficient surface supply, continuing records should be kept of the amount of water pumped, of water-level measurements, and of the location and performance of irrigation wells.

LITERATURE CITED

Bryan, Kirk, 1938, Geology and ground-water conditions of the Rio Grande depression in Colorado and New Mexico *in* National Resources Committee, Regional Planning, Part 6, The Rio Grande joint investigation in the upper Rio Grande basin in Colorado, New Mexico, and Texas, 1936–37, v. 1, p. 197–225.

Dunham, K. C., 1935, The geology of the Organ Mountains, N. Mex.: New Mexico School of Mines Bull. 11, 272 p.

Follansbee, Robert, Dean, H. J., Follett, W. W., and Gray, G. A., 1915, Water resources of the Rio Grande basin, 1888–1913: U. S. Geol. Survey Water-Supply Paper 358.

Fleming, B. P., and Stoneking, J. B., 1909, Tests of pumping plants in New Mexico: New Mexico College of Agr. and Mech. Arts, Bull. 73.

International Boundary and Water Commission, United States and Mexico, 1946, Flow of the Rio Grande and tributary contributions, 1946: Water Bull. 16.

Lee, W. T., 1907, Water resources of the Rio Grande valley in New Mexico and their development: U. S. Geol. Survey Water-Supply Paper 188.

Meinzer, O. E., 1923, The occurrence of ground water in the United States, with a discussion of principles: U. S. Geol. Survey Water-Supply Paper 489.

National Resources Committee, 1938, Regional Planning, Part 6, The Rio Grande joint investigation in the upper Rio Grande basin in Colorado, New Mexico, and Texas, 1936–37, v. 1.

New Mexico Agricultural Experiment Station, 46th Ann. Rept., 1934–35.

New Mexico State Engineer, Seepage study on Rio Grande between Elephant Butte Dam and Leasburg Dam, November 1928: 9th Bienn. Rept., 1928–30.

Public Health Service, 1946, Drinking water standards, 1946: Public Health Repts., Repr. 2697, v. 61, no. 11.

Sayre, A. N., and Livingston, Penn, 1945, Ground-water resources of the El Paso area, Texas: U. S. Geol. Survey Water-Supply Paper 919.

Scofield, C. S., 1938, Quality of water of the Rio Grande basin above Fort Quitman, Tex.: U. S. Geol. Survey Water-Supply Paper 839.

Slichter, C. S., 1905, Observations on the ground waters of the Rio Grande valley: U. S. Geol. Survey Water-Supply Paper 141.

Theis, C. V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage: Am. Geophys. Union Trans., v. 16, pt. 2, p. 519–524.

————1938, Ground water in the middle Rio Grande valley, in New Mexico, *in* National Resources Committee, Regional Planning, Part 6, The Rio Grande joint investigation in the upper Rio Grande basin in Colorado, New Mexico, and Texas, 1936–37, v. 1, p. 268–291.

————1941, The effect of a well on the flow of a nearby stream: Am. Geophys. Union Trans., v. 22, pt. 3, p. 734–738.

White, W. N., Broadhurst, W. L., and Lang, J. W., 1946, Ground water in the High Plains of Texas: U. S. Geol. Survey Water-Supply Paper 889–F.

Wilcox, L. V., 1948, Explanation and interpretation of analysis of irrigation waters: U. S. Dept. Agr. Circ. 784.

RECORDS

Table 1.—*Annual flow and depletion of the Rio Grande, 1930–46, in thousands of acre-feet*

[Water Bulletins 13-16, International Boundary and Water Commission, United States and Mexico and U. S. Bureau of Reclamation, El Paso, Tex.]

Year	Flow passing			Depletion		
	Caballo Dam	Leasburg Dam	El Paso station	Rincon Valley	Mesilla Valley	Rincon and Mesilla Valleys
1930	[1]799.9	790.5	532.7	9.4	257.8	267.2
1931	[1]776.0	740.7	517.8	35.3	222.9	258.2
1932	[1]854.0	816.0	567.2	38.0	248.8	286.8
1933	[1]829.0	824.0	609.2	5.0	214.8	219.8
1934	[1]813.9	768.2	508.5	45.7	259.7	305.4
1935	[1]649.1	633.0	459.9	16.1	173.1	189.2
1936	[1]757.9	693.3	473.8	64.6	219.5	284.1
1937	[1]798.3	740.8	536.2	57.5	204.6	262.1
1938	780.4	746.8	554.9	33.6	191.9	225.5
1939	789.1	737.5	511.6	51.6	225.9	277.5
1940	731.9	689.8	435.9	42.1	235.9	278.0
1941	703.5	685.9	511.4	17.6	174.5	192.1
1942	1,795.6	1,764.1	1,559.2	31.5	204.9	236.4
1943	911.8	861.0	631.8	50.8	229.2	280.0
1944	866.5	801.0	611.9	65.5	189.1	254.6
1945	882.8	814.2	568.9	68.6	245.3	313.9
1946	763.9	734.8	497.9	29.1	236.9	266.0
Average	853.1	814.2	594.5	38.9	219.7	258.6
Average (except 1942)	794.2	754.8	534.2	39.4	220.6	260.0

[1]Percha Dam.

Table 2.—*Releases from Caballo Reservoir as represented by monthly flow of the Rio Grande at "Below Caballo Dam" gage, 1938-46, in thousands of acre-feet*

[Water Bulletins 13 to 16, International Boundary and Water Commission, United States and Mexico]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1938	3.1	22.2	73.8	116.0	113.0	121.0	109.0	131.0	43.8	26.1	12.1	9.3	780.4
1939	.2	20.0	76.0	106.0	105.0	121.0	128.0	118.0	76.8	19.3	10.1	8.7	789.1
1940	.1	12.7	84.3	110.4	91.5	114.3	129.1	114.3	68.8	2.8	3.4	.1	731.9
1941	.1	7.3	49.3	115.0	93.0	117.0	129.0	110.0	62.4	4.2	5.7	10.6	703.5
1942	4.8	64.3	88.7	212.0	412.0	354.0	234.0	179.0	181.0	35.4	14.4	16.0	1,795.6
1943	4.9	32.2	95.1	138.7	123.5	131.3	125.3	153.5	70.4	19.1	12.0	5.8	911.8
1944	.3	20.4	89.2	136.0	115.0	124.0	134.0	137.0	86.1	16.1	.3	8.1	866.5
1945	.7	22.9	85.2	129.0	112.0	122.0	141.0	132.0	98.3	11.1	9.5	19.1	882.8
1946	.3	18.2	82.3	119.0	97.2	120.0	138.0	130.0	34.5	10.9	7.5	6.0	763.9
Average	1.6	24.5	80.4	131.3	140.2	147.2	140.8	133.9	80.2	16.1	8.3	9.3	913.9
Average minus 1942	1.2	19.5	78.2	121.2	106.3	121.3	129.2	128.2	67.6	13.7	7.6	8.5	802.5
Percent	.1	2.4	10.1	15.1	13.2	15.1	16.0	15.9	8.4	1.7	.9	1.0	99.9

Table 3.—*Gross diversions from the Rio Grande to the divisions of the Rio Grande project and to Mexico, 1930–46, in thousands of acre-feet*

[From U. S. Bureau of Reclamation, El Paso, Tex., except Acequia Madre from Water Bulletins 13 to 16, International Boundary and Water Commission, United States and Mexico]

Year	Percha Dam (Rincon Valley)	Leasburg Dam	Mesilla Dam	Mesilla Valley	El Paso Valley[1]	Acequia Madre (Valle de Juarez)
1930	100.0	231.1	351.2	582.3	385.7	....
1931	98.6	211.0	353.8	564.8	353.2	....
1932	98.0	220.0	353.5	573.5	347.6	....
1933	97.3	224.0	336.7	560.7	349.0	....
1934	108.9	210.5	315.4	525.9	372.1	....
1935	66.7	123.1	222.8	345.9	308.6	....
1936	78.4	155.2	269.0	424.2	393.6	....
1937	77.9	151.9	277.0	428.9	423.5	....
1938	79.2	151.0	289.8	440.8	427.4	60.4
1939	84.2	164.8	321.8	486.6	387.0	60.6
1940	80.9	154.8	292.4	447.2	386.3	58.2
1941	72.8	139.1	270.5	409.6	418.9	55.3
1942	101.0	192.4	349.6	542.0	435.4	83.9
1943	105.2	219.9	330.6	550.5	500.8	61.3
1944	108.2	204.4	314.9	519.3	448.9	61.8
1945	103.8	218.1	328.2	546.3	408.7	60.7
1946	99.6	205.7	303.3	509.0	375.1	60.5
Average	91.8	186.9	310.6	497.5	392.5	62.5

[1]Computed from reported acreages and headgate diversions in acre-feet per acre.

Table 4.—*Acreage irrigated and distribution of diversions for Rio Grande project, New Mexico and Texas, as reported, 1930–46*

Year	Acres irrigated	Headgate diversion (acre-feet per acre)	Canal waste or return (percent)	Canal and unaccounted-for losses (percent)	Delivered to farms	
					percent	acre-feet per acre
			Rincon division			
1930	12,702	7.9	35	37	28	2.22
1931	13,069	7.5	35	42	23	1.74
1932	12,463	7.9	24	49	27	2.07
1933	12,283	7.9	29	47	24	1.89
1934	12,776	8.5	25	46	29	2.51
1935	11,834	5.6	23	42	35	1.98
1936	13,528	5.8	20	34	46	2.64
1937	14,462	5.4	22	33	45	2.45
1938	14,152	5.6	21	36	43	2.38
1939	14,336	5.9	24	29	47	2.78
1940	14,813	5.5	20	29	51	2.78
1941	15,280	4.7	21	30	49	2.30
1942	15,916	6.4	25	34	41	2.61
1943	16,265	6.4	19	34	47	3.03
1944	16,049	6.7	22	34	44	2.98
1945	16,272	6.4	15	36	49	3.12
1946	17,000	5.9	14	38	48	2.79
Average	14,306	6.47	23.2	37.0	39.8	2.49

Table 4.—*Acreage irrigated and distribution of diversions for Rio Grande project, New Mexico and Texas, as reported, 1930–46*—Continued

Year	Acres irrigated	Headgate diversion (acre-feet per acre)	Canal waste or return (percent)	Canal and unaccounted-for losses (percent)	Delivered to farms	
					percent	acre-feet per acre
			Leasburg division			
1930	28,061	8.2	35	33	32	2.62
1931	28,289	7.5	35	32	33	2.51
1932	28,569	7.7	30	36	34	2.63
1933	29,713	7.5	32	37	31	2.30
1934	25,531	8.2	23	37	40	3.28
1935	22,706	5.4	19	33	48	2.59
1936	27,670	5.6	14	32	54	3.00
1937	28,387	5.4	16	26	58	3.09
1938	25,907	5.8	16	31	53	3.08
1939	27,075	6.1	15	28	57	3.48
1940	28,811	5.4	16	26	58	3.12
1941	28,811	4.8	14	33	53	2.58
1942	28,942	6.6	24	34	42	2.74
1943	30,060	7.3	19	34	47	3.36
1944	32,081	6.4	17	35	48	3.06
1945	31,734	6.9	12	36	52	3.57
1946	31,765	6.5	8	44	48	3.14
Average	28,477	6.55	20.3	33.4	46.4	2.95
			Mesilla division			
1930	48,312	7.3	23	44	33	2.37
1931	48,433	7.3	25	46	29	2.12
1932	48,140	7.3	19	49	32	2.35
1933	47,348	7.1	21	45	34	2.37
1934	43,074	7.3	16	44	40	2.90
1935	39,469	5.6	11	44	45	2.52
1936	47,143	5.7	12	40	48	2.73
1937	49,223	5.6	12	34	54	3.01
1938	47,592	6.1	16	38	46	2.80
1939	46,959	6.7	12	40	48	3.28
1940	46,566	6.0	12	36	52	3.24
1941	50,050	5.4	15	37	48	2.58
1942	52,275	6.4	24	37	39	2.61
1943	52,585	6.3	21	30	49	3.10
1944	50,768	6.2	14	34	52	3.21
1945	51,537	6.4	13	31	56	3.57
1946	52,146	5.7	10	34	56	3.28
Average	48,331	6.38	16.2	39.0	44.8	2.83

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Table 4.—*Acreage irrigated and distribution of diversions for Rio Grande project, New Mexico and Texas, as reported, 1930–46*—Continued

Year	Acres irrigated	Headgate diversion (acre-feet per acre)	Canal waste or return (percent)	Canal and unaccounted-for losses (percent)	Delivered to farms	
					percent	acre-feet per acre
			El Paso Valley			
1930	52,122	7.4	33	28	38	2.86
1931	50,455	7.0	30	34	36	2.53
1932	48,277	7.2	28	36	36	2.63
1933	49,862	7.0	30	28	42	2.93
1934	47,711	7.8	27	33	40	3.15
1935	46,066	6.7	30	34	36	2.41
1936	50,460	7.8	43	23	34	2.67
1937	52,939	8.0	42	23	35	2.78
1938	49,703	8.6	48	23	29	2.47
1939	51,597	7.5	25	36	39	2.90
1940	52,921	7.3	21	39	40	2.91
1941	53,709	7.8	42	30	28	2.18
1942	54,425	8.0	38	33	29	2.32
1943	55,032	9.1	31	35	34	3.09
1944	55,424	8.1	37	27	36	2.93
1945	55,232	7.4	27	27	46	3.38
1946	55,988	6.7	30	21	49	3.23
Average	51,876	7.61	33.0	30.0	36.9	2.79
			Rio Grande project			
1930	141,197	7.6	30	36	34	2.58
1931	140,246	7.2	29	39	32	2.31
1932	137,449	7.4	24	42	34	2.48
1933	139,206	7.2	25	40	35	2.51
1934	129,092	7.8	22	40	38	3.03
1935	120,075	6.0	20	39	41	2.44
1936	138,801	6.4	26	31	43	2.75
1937	145,011	6.4	28	27	45	2.89
1938	137,354	6.9	30	31	39	2.69
1939	139,967	6.8	19	35	46	3.13
1940	143,111	6.3	17	35	48	3.05
1941	147,860	6.1	28	33	39	2.40
1942	151,558	7.0	28	36	36	2.53
1943	153,942	7.4	24	36	42	3.14
1944	154,322	6.9	24	32	44	3.06
1945	154,775	6.8	18	31	51	3.46
1946	156,899	6.2	17	32	51	3.18
Average	142,992	6.85	24.1	35.0	41.1	2.80

Table 5.—*Flow of drains to the Rio Grande in Rincon and Mesilla Valleys, N. Mex. and Tex.*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Rincon Valley													
1930	1,543	1,666	2,601	3,153	3,228	3,296	3,800	3,627	3,101	2,263	1,904	1,752	31,934
1931	1,463	1,722	2,540	3,439	3,504	3,927	4,463	4,095	3,885	2,921	2,553	2,207	36,719
1932	1,917	2,014	2,835	3,951	4,360	4,409	4,021	4,532	4,082	3,117	1,952	2,104	39,294
1933	1,605	1,692	2,638	4,006	3,831	3,963	4,426	5,386	4,772	3,382	2,642	2,681	41,024
1934	2,035	2,421	3,419	4,653	4,513	4,653	4,802	4,236	3,701	2,472	1,987	1,980	40,872
1935	1,599	1,428	1,820	2,565	2,397	2,586	3,321	3,228	2,832	2,011	1,696	1,439	26,922
1936	1,408	1,387	1,919	2,838	2,859	2,898	3,615	3,929	3,034	1,906	1,416	1,421	28,630
1937	1,235	1,289	1,882	3,004	3,474	3,213	3,419	4,021	3,189	2,214	1,696	1,612	30,248
1938	1,457	1,422	2,188	2,951	3,118	3,349	3,149	3,610	3,588	2,656	1,945	1,925	31,358
1939	1,641	1,643	2,564	3,659	3,634	3,784	3,776	3,682	3,618	2,729	2,035	1,881	34,646
1940	1,667	1,426	2,527	3,547	3,579	3,713	3,885	4,169	3,623	2,299	1,750	1,396	33,581
1941	1,322	1,188	1,630	3,434	3,720	2,903	4,218	4,372	3,511	2,933	1,922	1,813	33,966
1942	1,556	1,727	2,700	4,315	4,790	4,546	5,319	5,669	4,564	3,468	2,678	2,515	43,847
1943	2,201	2,150	3,308	4,421	4,650	4,665	4,939	5,196	4,350	3,302	2,361	2,053	43,596
1944	1,660	1,466	2,490	3,475	3,818	3,791	4,526	5,084	4,189	2,736	1,738	1,704	36,677
1945	1,420	1,370	2,080	3,540	3,940	3,780	4,060	4,400	3,890	2,670	1,930	1,740	34,820
1946	1,560	1,310	2,130	3,650	3,480	3,680	4,530	4,790	3,450	2,150	1,770	1,450	33,950
Average	1,605	1,607	2,428	3,565	3,700	3,774	4,133	4,354	3,728	2,660	1,998	1,863	35,416
Percent	4.5	4.5	6.9	10.1	10.4	10.7	11.7	12.3	10.5	7.5	5.6	5.2	99.9
Mesilla Valley													
1930	8,602	8,624	12,857	17,548	18,483	18,762	21,416	20,020	19,643	15,408	11,526	10,884	183,773
1931	9,230	8,664	13,723	18,903	19,824	20,838	22,910	22,363	20,851	15,163	12,788	11,289	196,546
1932	9,254	9,066	12,857	17,071	18,606	19,683	21,104	23,210	23,834	16,178	12,150	11,345	194,358
1933	9,807	8,826	14,382	18,936	19,990	19,761	22,128	23,888	22,064	19,485	13,549	12,549	205,365
1934	9,880	9,670	18,840	20,791	23,101	24,291	25,378	25,857	21,607	15,876	12,281	10,213	217,785
1935	9,709	8,181	10,004	14,174	15,556	15,661	18,446	19,978	17,857	15,003	11,596	10,915	167,080
1936	9,623	8,727	11,283	15,524	18,088	18,442	21,797	23,027	19,816	15,594	12,370	10,913	185,204
1937	9,512	8,375	11,485	16,019	18,033	18,149	19,880	22,247	19,029	14,567	11,811	11,313	180,420
1938	10,378	9,141	12,426	15,155	17,623	18,430	19,911	21,416	19,376	16,565	13,364	12,094	185,879
1939	10,422	9,374	14,025	19,441	20,972	21,892	25,345	25,185	23,354	19,435	14,768	13,177	217,390
1940	10,858	9,772	14,634	19,797	22,443	24,278	27,257	27,239	25,575	18,809	13,227	11,589	225,478
1941	10,169	8,342	11,337	18,387	21,060	22,589	26,298	25,873	25,062	19,313	14,060	13,065	215,555
1942	10,840	11,273	14,227	20,917	24,859	24,534	26,913	27,934	24,349	20,014	15,798	14,265	235,923

Table 5.—*Flow of drains to the Rio Grande in Rincon and Mesilla Valleys, N. Mex. and Tex.*—Continued

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Mesilla Valley—Continued													
1943	11,991	11,219	16,085	22,850	26,447	26,699	29,976	31,949	28,794	20,765	15,990	14,149	256,914
1944	12,285	11,170	17,192	23,968	25,771	26,716	31,494	34,040	29,599	23,671	16,762	13,310	265,978
1945	11,840	11,230	15,110	22,000	23,980	26,560	30,440	33,400	29,610	22,850	17,650	14,830	259,500
1946	13,060	9,760	13,770	22,060	25,070	26,990	30,990	32,700	26,520	17,520	13,620	12,800	244,860
Average	10,439	9,495	13,778	19,032	21,171	22,016	24,805	25,902	23,349	18,013	13,724	12,276	214,000
Percent	4.9	4.4	6.4	8.9	9.9	10.3	11.6	12.1	10.9	8.4	6.4	5.7	99.9

Table 6.—*Drillers logs of wells in parts of Sierra and Dona Ana Counties, N. Mex.*

16.5.23.300. O. B. Dawson

[Casing perforated from 105 ft to 215 ft]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Clay and gravel	37	37	Clay	11	171
Sand and gravel (water)	2	39	Gravel (water)	5	176
Clay and caliche	33	72	Clay with sand	3	179
Sand (water)	1	73	Water (increased flow)	3	182
Clay and sandstone (?) stringers	42	115	Pure clay	4	186
Sand (water)	2	117	Gravel (water—greatest portion of flow)	12	198
Clay and sand stringers	23	140	Hard sandstone (?)	7	205
Sand (water)	1	141	Clay	8	213
Clay and sand	11	152	Sand and gravel (water)	1	214
Gravel (water flow started)	8	160	Hard sandstone (?)	11	225
			Dry clay	1	226

16.5.25.120. U. S. Department of the Interior, Bureau of Reclamation (Caballo Dam)

[Casing perforated from 38 ft to 105 ft]

Topsoil, gravel, clay, and boulders	35	35	Soft fine sand (water at 45 ft, additional water at 97 ft, rose to 35 ft)	33	105
Fine sand	30	65	Sandy conglomerate with hard streaks	31	136
Clay-bound conglomerate	7	72			

16.5.25.343. A. J. Osborn

Hard dirt	38	38	Soft red rock	24	152
Fine sand and small gravel	90	128			

17.4.30.133a. W. B. Cantrell

Gravel and clay	4	4	Sand	4	55
Clay	8	12	White clay	4	59
Gravel and clay	6	18	Sand and gravel	2	61
Gravel (water)	2	20	Conglomerate rock	2	63
Sand and gravel	3	23	Gravel	7	70
Gravel	15	38	Red clay	1	71
Sand	2	40	White clay conglomerate	11	82
Gravel	2	42	Red clay	1	83
Sand	3	45	White clay conglomerate	13	96
Sand and gravel	6	51	White clay	1	97

17.4.31.111. Ben Luchini

Sugar sand	10	10	Gravel with some sand (water)	5	60
Sand (water)	10	20	Red clay	3	63
Sand and gravel (water)	15	35	Rock and gravel	3	66
Sand and coarse gravel (water)	18	53	Red and white clay, gray sand	5	71
Red clay	2	55			

17.5.24.333. E. W. Powers

Sand and boulders (arroyo deposits)	35	35	Dirt	10	55
Sand (water)	10	45	Sand and gravel (water)	18	73
			Red gumbo clay	28	101

17.5.26.242. Lloyd Welch

Gravel (water)	52	52	Gravel (water)	27	84
Clay	5	57	Clay	4	88

18.4.35 221. Boggs

Sand and gravel with clay stringers	111	111	Water between hard formation, limestone above and clay below	2(?)	114
Hard rock formation resembling limestone	1	112	Red-brown clay	100	214

Table 6.—*Drillers logs of wells in parts of Sierra and Dona Ana Counties, N. Mex.*—Continued

19.2E.33.140b. U. S. Department of the Interior, Bureau of Reclamation (Jornada Experimental Range)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Topsoil	7	7	Pack sand	85	175
White sugar sand	13	20	Red shale	135	310
Light-gray shale	10	30	Quicksand	35	345
Sand and caliche	30	60	Soft red sandstone	15	360
Reddish-brown shale	30	90			

19.2.3.122. Atchison Topeka & Santa Fe Railway Co.

[Casing perforated from 170 ft to 259 ft]

Sand	27	27	Sand with gravel and clay balls	22	230
Gravel	8	35	Sand and clay	4	234
Sand and gravel	99	134	Sand	6	240
Fine sand	21	155	Clay and sand	8	248
Soupy coarse sand	25	180	Sand	9	257
Sand and gravel	4	184	Blue clay	3	260
Soupy coarse sand	16	200			
Clay and sand	8	208			

19.3.15.443. I. W. Smallwood

Clay and sandy loam	10	10	Red clay	3	43
Sand	12	22	Gravel	3	46
Sand and gravel	18	40	Red clay	6	52

19.4.11.221. Clyde Cowan

Soil	16	16	Coarse grayish sand, some small gravel	15	70
Quicksand (came up in casing)	39	55	Tough red clay	4	74

20.1E.14.140. U. S. Department of the Interior, Bureau of Reclamation (Jornada Experimental Range)

Topsoil	5	5	Sand	33	280
Limerock and caliche	40	45	Light-blue sandy shale	8	288
Conglomerate rock and sand	70	115	Alternate layers of clay and sand	35	323
Yellow clay	10	125	Quicksand (very little water)	7	330
Sand	60	185	Layers of clay and sand	18	348
Red bird's eye clay	15	200	Sandstone (water)	8	356
Pack sand	35	235			
Blue clay	12	247			

20.1.10. New Mexico College of Agriculture and Mechanic Arts

Caliche	20	20	Yellow clay	7	197
Dry falling sand	20	40	Sand	27	224
Conglomerate rock	7	47	Sandstone	6	230
Yellow clay, gravel	13	60	Sand	70	300
Coarse sand	12	72	Sandstone	12	312
Pack sand	8	80	Quicksand (water)	8	320
Dry falling sand	110	190			

21.1.13.323. Isaac Rhodes

Soil and sand	29	29	Gravel	10	58
Gravel	7	36	Blue gumbo or clay	35	93
Clay	12	48	Rock	122	215

Table 6.—*Drillers logs of wells in parts of Sierra and Dona Ana Counties, N. Mex.*—Continued

22.1E.10.413. E. A. Knight

[Casing perforated from 50 ft to 60 ft]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Gravel and silt	5	5	Wet clay with gravel	17	79
Sandy soil	15	20	Dry clay and gravel	43	122
Sand (water at 25 ft)	20	40	Fine sand (water level rose)	3	125
Fine gravel and sand	5	45	Dry clay and gravel	5	130
Coarse gravel	17	62			

22.1E.26.214. J. K. Nakayama

[Casing perforated from 30 ft to 52 ft]

Topsoil	6	6	Clay	3	67
Sand	24	30	Fine sand	25	92
Coarse gravel	15	45	Sticky clay	5	97
Fine gravel and sand	5	50	Sandstone	3	100
Sand	14	64			

21.2E.12.222. Edwin Parker

Topsoil	2	2	Sandstone (water)	11	381
Sand, clay, and caliche	3	5	Clay and sand	5	386
Sandstone (?)	4½	9½	Sandstone (water)	9	395
Clay	1½	11	Clay and sandstone	4	399
Sandstone	9	20	Sandstone	4	403
Lime	23	43	Clay	1	404
Conglomerate rock, gravel	6	49	Sandstone (water)	9	413
Conglomerate	27	76	Limerock	17½	430½
Conglomerate and hard sand	4	80	Sandrock	2½	433
Caliche, clay, and sand	3	83	Sandstone	12	445
Sandrock	2	85	Sand	3	448
Clay and caliche	25	110	Conglomerate sand and sandstone	26	474
Adobe and sand	11	121	Sandstone and lime	4	478
Clay	26	147	Sand	3	481
Limestone	2	149	Sandstone and lime	4	485
Clay	28	177	Sand	1	486
Clay and sand	2	179	Limerock	1	487
Clay	19	198	Sandstone	4	491
Clay and sand	10½	208½	Lime	10	501
Sandstone	10½	219	Clay	3	504
Clay and sandstone	68	287	Limestone	38	542
Sandstone	2	289	Shale	4	546
Clay	2	291	Lime and quartz	3	549
Clay and sand	37	328	Shale	2	551
Clay	4	332	Limestone	80	631
Sandstone	3	335			
Clay and sand (small amount of water)	35	370			

23.1.15.211. Picacho Oil and Gas Syndicate

[Old oil test, abbreviated log]

Sand and caliche	30	30	Brown gummy shale	25	865
Coarse sand and pink shale	130	160	Red rock	13	878
Red rock	15	175	Soft brown sandy lime	7	885
Very sticky, light-blue, gummy mud	5	180	Hard gray lime	5	890
Brown sand	5	185	Soft sandy lime	10	900
Sandy blue mud	20	205	Sandy red shale and lime	45	945
Blue marl	345	550	Gray, brown, and blue shale	30	975
Shale and lime	14	564	Third water (large amount of water rose in hole to 200 ft from top)	10	985
Blue gumbo, streaks of lime	34	598	Brown lime and shale	50	1,035
Sandy lime (first water)	22	620	Hard sand (best water)	10	1,045
Bedded blue marl	25	645	Brown lime and shale	69	1,114
Blue marl and gumbo	5	650	Blue and gray lime and shale	84	1,198
Sandy shale (second water)	4	654	Red limerock	32	1,230
Blue and gray sandy lime and shale	186	840	Hard gray lime	5	1,235

Table 6.—*Drillers logs of wells in parts of Sierra and Dona Ana Counties, N. Mex.*—Continued

23.1.15.211. Picacho Oil and Gas Syndicate— Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Brown sandy lime and shale (salt water at 1,335 ft)	280	1,515	Sandy lime	12	2,852
Blue and red lime and shale	95	1,610	Rotten black shale	10	2,862
Brown shale	205	1,815	Sandy lime streaks of shale	22	2,884
Gray-blue lime and shale	805	2,620	Blue sandy shale	6	2,890
Sand (hot water)	20	2,640	Hard black lime and sandy shale	53	2,943
Dark shale	70	2,710	Red sand	3	2,946
Hard lime and black shale	90	2,800	Hard gray, brown, white, and black lime	124	3,070
Black slatey crystallized shale	40	2,840	Pink sandy shale	3	3,073
			White chalky lime	123	3,196

23.1.32.330. H. S. Bissell

Sand and gravel	165	165	Sandstone	110	430
Malpais	155	320	Rusty-colored sand	71	501

23.3.4.140. H. S. Bissell

Sand, shale, and clay	200	200	Hard blue rock (malpais) (water 600 to 900 ft)	510	1,005
Hard rock and gray and blue shale (malpais)	295	495			

23.1E.13.144. City of Las Cruces (Hadley Street well)

Soil	10	10	Sandy clay	20	110
Sand and coarse gravel	15	25	Sand and small gravel	55	165
Coarse sand	65	90	Sticky clay	10	175

23.1E.13.244. Atchison Topeka & Santa Fe Railway Co.

[Backfilled to 82 ft]

Fine sand and boulders (water)	62	62	Sand and boulders (water)	18	220
Clay parting	0	62	Soft white clay	3	223
Fine sand and boulders (water)	58	120	Light-blue clay	3	226
Clay parting	0	120	White sandy clay	8	234
Fine sand and boulders (water)	45	165	Fine sand (water)	7	241
Sticky blue clay	4	169	White sandy clay	2	243
Sand and boulders (water)	31	200	Fine sand (water)	8	251
Soft sandrock	2	202			

23.2E.6.332. Fay Sperry

Sand and gravel	101	101	Sand (water)	23	126
Sticky clay	2	103	Hard clay	7	133

23.2E.6.332a. Fay Sperry

Sand	3	3	Sand	10	110
Sand and gravel	52	55	Clay	15	125
Sand (water)	23	78	Medium to coarse sand (water)	5	130
Sand and gravel	17	95			
Boulders	5	100			

23.2E.8.434. City of Las Cruces (well 5)

[Casing perforated from 210 ft to 250 ft; screen 262 ft to 285 ft]

Sand and large gravel	60	60	Clay	15	270
Sand and small gravel	35	95	Coarse gravel and sand (water)	20	290
Packed sand with thin strips of gravel	105	200	Pure clay	10	300
Sand, gravel, and clay mixture (water at 200 ft.)	55	255			

Table 6.—*Drillers logs of wells in parts of Sierra and Dona Ana Counties, N. Mex.*—Continued

23.2E.17.210. City of Las Cruces (well 1)

[Screen from 275 ft to 294 ft]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand and gravel	45	45	Quicksand interbedded with shale layers 2 to 4 ft thick (water)	65	245
Conglomerate rock	30	75	Red shale rock and gravel	5	250
Packed sand	5	80	Red shale	28	278
Conglomerate rock	38	118	Gravel (water)	16	294
Quicksand (very little water)	4	122			
Packed sand	58	180			

23.2E.17.210b. City of Las Cruces (well 3)

[Screen from 272 ft to 291 (?) ft]

Sand and gravel	42	42	Packed sand	70	245
Conglomerate rock	28	70	Gray shale interbedded with gravel	27	272
Packed sand with conglomerate rock	26	96	Coarse gravel (water)	2	274
Gray-brown sandstone	9	105	Gray shale with some gravel and sandstone (water)	12	286
Packed sand with conglomerate rock	70	175			

23.2E.29.243 New Mexico College of Agriculture & Mechanic Arts (well 2, domestic)

Red clay and some fine sand	32	32	Yellow clay	4	151
Gravel and white sand	10	42	Sand and gravel	20	171
Fine sand, 80 percent dark, 20 percent white	40	82	Fine sand, 90 percent dark	35	206
Sand, some gravel	5	87	Sand and gravel	5	211
Fine sand, 80 percent dark, 20 percent light	60	147	Red clay	9	220
			Very large gravel and boulders	8	228

23.2E.29.243b. New Mexico College of Agriculture & Mechanic Arts

[Plugged at 81 ft with concrete; casing perforated from 52 ft to 72 ft]

Clay and sand (water)	50	50	Clay and sand	8	83
Large loose rock and gravel with coarse sand	25	75	Fine dark quicksand (ran into well)	0	83

23.2E.29.243c. New Mexico College of Agriculture & Mechanic Arts (well 4, domestic)

Soil	5	5	Coarse sand	2	182
Gravel and soil	5	10	Dark-colored material	23	205
Gravel, soil, and clay	25	35	Dark-colored sand	4	209
Sand and large gravel (water at 35 ft, rose to 31 ft)	25	60	Very hard dark-colored material	46	255
Clay, gravel, and sand (no water	20	80	Softer dark-colored material	5	260
Fine sand	41	121	Hardest dark-colored material	15	275
Sand with trace of gravel	4	125	Hard material	7	282
Fine sand	30	155	Red clay, quartz crystals	3	285
Conglomerate gravel and rock	5	160	Dark clay	7	292
Very hard dark-colored material	20	180	Sand, gravel, and clay	13	305

23.2E.30.412c. New Mexico College of Agriculture & Mechanic Arts

[Screen from 22 ft to 92 ft]

Soil	4	4	Clay	2	88
Clay	22	26	Sand, clay	7	95
Sand and gravel	60	86			

Table 6.—*Drillers logs of wells in parts of Sierra and Dona Ana Counties, N. Mex.*—Continued

24.1E.1.111. Stahman Farms, Inc. (well 1)

[Test hole from 306 ft to 331 ft]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soft reddish-brown topsoil and sand	10	10	Soft sand	1	224
Soft reddish-brown quicksand	34	44	Hard yellow clay and gravel	4	228
Medium-hard gravel	42½	86½	Medium-hard yellow sand	7	235
Soft reddish-brown sand	7½	94	Medium-hard gravel	2	237
Medium-hard gravel	4	98	Medium-hard blue clay	8	245
Soft brown sand	1	99	Soft sand	1	246
Hard gravel	5	104	Medium-hard yellow clay	1	247
Hard red shale	14	118	Soft sand	5	252
Soft brown sand	7	125	Soft yellow clay	2	254
Medium-hard reddish-brown sandy clay	6	131	Hard sandrock	1	255
Soft brown sand	7	138	Soft sand	13	268
Hard clay and gravel	½	138½	Hard sandrock	1	269
Soft brown sand	6	144½	Soft sand	2	271
Medium-hard red clay	½	145	Medium-hard gravel (small)	2	273
Soft sand	3	148	Soft black sand	2	275
Medium-hard yellow clay	1	149	Medium-hard gravel and clay	5	280
Soft sand	18	167	Soft black sand	5	285
Medium-hard yellow clay	8	175	Medium-hard yellow clay and gravel	2	287
Hard red sandstone	1	176	Soft black sand	6	293
Soft reddish-brown sand	10	186	Medium-hard yellow clay and gravel	1	294
Medium-hard yellow clay and gravel	1	187	Soft sand	1	295
Soft sand	12	199	Medium-hard brown clay	2	297
Soft gravel	2	201	Soft sand	2	299
Soft yellow clay	1	202	Medium-hard brown clay	1	300
Medium-hard yellow clay and gravel	1	203	Soft sand	3	303
Soft sand	4	207	Medium-hard yellow clay	2	305
Soft yellow clay and gravel	2½	209½	Soft sand	1	306
Soft sand	8	217½	Medium-hard sandrock, sand, and gray conglomerate	9	315
Medium-hard yellow clay	½	218	Medium-hard yellow clay	4	319
Soft sand	2	220	Soft black quicksand	12	331
Soft yellow clay	3	223			

24.3W.8.310. H. S. Bissell

Sand and gravel	72	72	Gravel, clay (water)	5	245
Sandy shale	28	100	Sandy shale	15	260
Soapstone	140	240	Soapstone	2	262

24.3W.25.230. H. S. Bissell

Red, blue, and gray shale	200	200	Hard red shale (water)	7	212
Red clay	5	205			

24.4.12.230. Biggs ranch

Surface formation	100	100	Sand and gravel	60	200
Hard blue formation	40	140			

26.3E.9.221 Berino Cotton Gin

Sand and gravel	80	80	Clay	36	148
Sand and clay	1	81	Sand	(?)	148+
Sand and gravel	31	112			

26.3E.19.432. Judo Yabumoto

[Test hole 90 ft to 131 ft]

Sand	33	33	Small and large gravel	27	86
Gray shale (?)	2	35	Hard gray clay, shale (?)	4	90
Sand and a little gravel	24	59	Sand	41	131

Table 6.—*Drillers logs of wells in parts of Sierra and Dona Ana Counties, N. Mex.*—Continued

26.3E.30.114. O. E. Egbert

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand	15	15	Coarse sand	7	75
Gravel	30	45	Sand and gravel	10	85
Clay	8	53	Gravel	22	107
Gravel, rock at 60 ft	12	65	Rock	....	107
Clay and sand	3	68			

26.1.4.410. Southern Pacific Co. (Afton)

Caliche	25	25	Fine sand (water)	188	515
Sand and gravel	75	100	Red clay	25	540
Fine sand	150	250	Yellow clay	45	585
Sand and caliche	20	270	Fine sand	43	628
Fine sand	26	296	Coarse sand and clay	27	655
Red clay with fine sand	31	327	Red clay	47	702

27.1E.11.330. Southern Pacific Co. (Lanark, well 1, center well)

Clay	229	229	Sandstone	10	849
Red and yellow clay	525	754	Red clay	53	902
Sand (water)	31	785	Sand	30	932
Clay	16	801	Clay	5	937
Sand	4	805	Sand	13	950
Clay and sand	34	839			

27.1E.11.330a. Southern Pacific Co. (Lanark, well 2, west well)

Sand	5	5	Sand	27	274
White sand	15	20	Red clay	4	278
Clay	10	30	Sand	62	340
Sand	50	80	Clay	18	358
Red clay	5	85	Sand	25	383
Sand	55	140	Clay	11	394
Red clay	10	150	Sand	9	403
Sand	20	170	Sandrock	12	415
Red clay	12	182	Sand (water 415 ft, rose to 365 ft)	100	515
Sand	30	212	Clay	15	530
Sandy clay	15	227	Sand	85	615
Clay	20	247			

27.1E.11.330b. Southern Pacific Co. (Lanark, well 3, east well)

Clay and soil	10	10	Sand	50	373
White shale	20	30	Clay	35	408
Clay	50	80	Sandstone	7	415
Sand and boulders	20	100	Sand	10	425
Clay	40	140	Sand (water at 425 ft, rose to 365 ft)	10	435
Cemented sand	12	152	Clay	30	465
Clay	30	182	Blue quicksand	55	520
Sand and gravel	20	202	Clay	30	550
Clay	50	252	Blue quicksand	30	580
Hardpan	32	284	Tough blue clay	20	600
Sand	9	293	Sandy blue clay	46	646
Clay	30	323			

27.3E.6.213. Chester Little

[Casing perforated from 60 ft to 80 ft]

Sand and soil	55	55	Clay	20	105
Large rounded boulders and gravel	30	85	Sandrock	10	115
			Quicksand	11	126

27.3E.15.143. Paul Price

[Screen from 50 ft to 90 ft]

Topsoil	5	5	Small gravel	48	90
Sand, some clay	37	42	Clay	1	91

Table 6.—*Drillers logs of wells in parts of Sierra and Dona Ana Counties, N. Mex.*—Continued

28.2E.24.110. Southern Pacific Co. (Strauss, well 1)

[Well later plugged back to 975 ft]

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Sand	3	3	Sand	5	523
Sandy soil	3	6	Yellow clay	4	527
Caliche	6	12	Sand	3	530
Sand	8	20	Yellow and blue clay	10	540
Yellow clay	85	105	Black sand	70	610
Cemented sand	15	120	Blue clay	20	630
Yellow clay	50	170	Black sand	20	650
Sand	15	185	Blue and red clay	120	770
Red clay	25	210	Black sand	60	830
Sand	5	215	Yellow clay	40	870
Red clay	22	237	Black sand	25	895
Cemented sand	13	250	Red clay	45	940
Yellow clay	5	255	Black sand	10	950
Sand	10	265	Red clay	30	980
Sandy clay	30	295	Sand	10	990
Sand	2	297	Red clay	20	1,010
Red clay	23	320	Sand	5	1,015
Sand	10	330	Red clay	20	1,035
Red clay	20	350	Sand	5	1,040
Sand	5	355	Red clay	40	1,080
Yellow clay	5	360	Sand	10	1,090
Sand (water)	52	412	Clay	35	1,125
Yellow clay	38	450	Sand and gravel (water)	15	1,140
Sand	25	475	Clay	10	1,150
Blue clay	3	478	Sand	125	1,275
Sand	7	485	Sandy clay	50	1,325
Yellow clay	3	488	Sandstone	2	1,327
Sand	10	498	Sand	3	1,330
Yellow clay	20	518			

28.2E.24.110a. Southern Pacific Co. (Strauss, well 2)

Sand	3	3	Cemented clay and sand in thin strata	20	367
Sandy soil	3	6	Sand	13	380
Caliche	6	12	Sandstone	2	382
Sand	8	20	Sand and clay in thin strata	38	420
Yellow clay	85	105	Sand	40	460
Cemented sand	15	120	Sand and clay in thin strata	23	483
Yellow clay	50	170	Clay	22	505
Sand	10	180	Soft blue clay	35	540
Clay	46	226	Soft cemented clay	25	565
Sand	22	248	Fine sand and clay	30	595
Clay	6	254	Clay	25	620
Sand	8	262	Sandy clay	70	690
Yellow sand	12	274	Clay with cement boulders	15	705
Clay	33	307			
Sand	13	320			
Packed sand	13	333			
Hard clay	14	347			

28.3E.25. Lippincott well

[Water-Supply Paper 919, p. 106]

Sand	49	49	Brown fine sand	42	410
Gravel	5	54	Blue sandy shale	43	453
Sand	31	85	Gumbo	17	470
Gravel	5	90	Fine sand	10	480
Sand	9	99	Shell lime	2	482
Broken gravel and sand	190	289	Gumbo	65	547
Coarse gravel and sand	21	310	Sandy shale	57	604
Very coarse gravel and sand (water test)	23	333	Gumbo and sand	218	822
Gravel, broken shale and sand	12	345	Hard sandy lime	3	825
Gravel, sand, and lime	10	355	Gumbo	40	865
Brown coarse sand	13	368	Hard sandy lime	3	868
			Very hard black lime	1	869

Table 6.—*Drillers logs of wells in parts of Sierra and Dona Ana Counties, N. Mex.*—Continued

28.3E.25. Lippincott well—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Lime, broken, with coarse gravel	71	940	Blue lime with seam	8	997
Hard gray lime	11	951	Cemented sand	7	1,004
Sandy limestone (some water)	3	954	Blue lime with sand seam	3	1,007
Blue lime	3	957	Yellow clay and sand seam (small flow of water)	10	1,017
Blue lime with sand seam	6	963	Soft yellow sandstone	9	1,026
Very hard solidified lime	1	964	Blue limestone	1	1,027
Sandy limestone	1	965	Clay, soft sandstone	7	1,034
Blue lime	2	967	Clay and yellow sand	3	1,037
Siliceous lime	3	970	Soft sandstone	20	1,057
Blue lime	4	974	Quicksand	5	1,062
Siliceous lime	3	977	Blue clay, sand	2	1,064
Blue lime with sand seam	9	986	Quicksand	10	1,074
Hard quartz	3	989			

29.1E.8.210a. Southern Pacific Co. (Noria, well 2)

Sand	40	40	Red clay and shale	35	500
Clay	5	45	Tough clay	10	510
Sand and gravel	235	280	Clay, shale, and packed sand	30	540
Red clay	95	375	Sand and boulders	11	551
Red clay and shale	30	405	Packed sand, clay, and shale	14	565
Shale and packed sand	30	435			
Sand, red clay, and shale	30	465			

29.1E.8.210b. Southern Pacific Co. (Noria, well 3)

Sand	3	3	Shale and shell rock	15	399
Chalk rock	12	15	Shale	19	418
Sand	85	100	Water sand	42	460
Fine sand	70	170	Shale	27	487
Sand and clay	110	280	Clay	18	505
Sand	83	363	Water sand	45	550
Clay	21	384	Clay and sand	15	565

29.2.6.230. Southern Pacific Co. (Mt. Riley, well 2)

[Well allowed to fill to 528 ft, August 1924]

Sand with streaks of soft white rock	110	110	Clay and gravel	10	560
Clay	60	170	Cemented gravel	5	565
Clay and sand	110	280	Cemented gravel, boulders	7	572
Sand (water)	20	300	Cemented boulders	10	582
Clay	25	325	Cemented gravel and boulders	33	615
Clay and gravel	95	420	Cemented gravel	5	620
Sand and gravel	7	427	Rock	10	630
Clay and gravel	106	533	Cemented gravel	85	715
Clay, gravel, loose rock	17	550			

29.4.9.100. Southern Pacific Co. (Malpais, well 1)

Clay	5	5	Clay	262	370
Malpais	103	108	Clay and sand	75	445

29.4.9.100a. Southern Pacific Co. (Malpais, well 2)

Caliche	12	12	Clay	42	365
Malpais boulder	20	32	Rock	1	366
Rock	56	88	Clay and sand	22	388
Clay and sand	98	186	Quicksand	5	393
Sandrock	13	199	Sand	34	427
Clay and sand	25	224	Hardpan	38	465
Clay	53	277	Clay	49	514
Clay and sand	46	323			

Table 7.—*Analyses of ground waters in parts*

[Analyses by U. S. Geological Survey[1], unless otherwise noted.

Well location no.	Owner or name	Date of collection 1947	Depth of well (feet)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)
			Wells drilled in arroyo deposits or			
16.5.22.420...	O. B. Dawson..............	(2)	216	32	22	2.9
Do.........	.........do.....................	(3)	216	....	21	4.4
Do.........	.........do.....................	June 7	216	25	22	2.5
16.5.23.300...	.........do.....................	June 7	226	....	....	....
Do.........	.........do.....................	July 31	226	28	24	1.6
16.5.25.120...	U. S. Dept. Interior, Bur. Reclamation.	(4)	138	....	53	7.3
17.5.14.212...	A. J. Osborn................	July 14	121	30	38	3.1
17.5.14.441...	Earl Riggs....................	Aug. 15	80	....	53	8.0
17.5.24.333...	E. W. Powers...............	Apr. 17	102	....	60	8.3
17.5.26.212...	Mickey Plemmons.........	July 14	68	24	66	8.0
19.4.11.221...	Clyde Cowan................	Apr. 17	74	....	267	53.
20.1.26.210...	New Mexico Coll. of Agr. & Mech. Arts.	May 17[5]	284	73	34	13.
21.1.11.431...	C. C. Rice....................	Mar. 26[5]	150	....	216	52.
22.1E.33.321..	K. H. Walker...............	Aug. 29	74	....	158	27.
22.2E.13.411..	J. W. Daugherty...........	Aug. 26[5]	430	....	34	7.
23.2E.6.323...	Las Cruces Country Club.	Aug. 13	200	....	58	17.
23.2E.8.434...	City of Las Cruces, well 5	May 6	300	....	124	32.
Do.........	.........do.....................	Mar. 25[5]	300	....	134	36.
23.2E.17.210..	City of Las Cruces.........	(6)	(7)	....	56	17.
23.2E.17.210a.	City of Las Cruces, well 2.	Mar. 25[5]	....	....	70	18.
24.3.5.330.....	H. S. Bissell................	Mar. 25[5]	....	....	15	9.4
26.3E.19.311..	Leslie Hayes................	Mar. 25[5]	132	....	43	12.
26.1.4.410.....	Southern Pacific Co. (Afton).	(8)	702	....	47	18.
26.1.25.410a..	Mrs. Annie Braidfoot......	May 1	460	....	5	3.2
27.1E.33.130..	.........do.....................	May 1	453	....	12	9.8
28.2E.24.110..	Southern Pacific Co. (Strauss).	(8)	950	....	20	9.0
28.2E.24.110a.	.........do.....................	May 1	705	....	24	10.
1 mile west of Cerro de Muleros.	Dr. J. E. Laws.............	(9)	....	....	33	6.2
			Wells drilled in alluvial fill			
17.4.31.111...	Ben Luchini...................	July 14	71	20	157	21.
19.3.4.331.....	B. S. Thurman.............	Apr. 18	52	....	138	30.
19.3.9.121a....	Village of Hatch...........	Aug. 12	70	....	91	15.
19.3.10.333...	E. L. Cocks..................	Aug. 11	69	....	200	29.
19.3.10.432...	Lee Stotts.....................	Aug. 15	68	....	86	15.
22.1E.26.214..	J. K. Nakayama...........	Aug. 27	100	....	164	27.
22.1E.28.140..	T. L. Simpson..............	Aug. 13	242	....	53	9.4
22.1E.28.310..	.........do.....................	Aug. 13	42	....	302	44.
22.1E.28.320..	.........do.....................	Aug. 13	162	....	98	17.
23.2E.18.141..	City of Las Cruces.........	(10)	....	32	161	24.
Do.........	.........do.....................	(11)	....	27	150	27.
Do.........	.........do.....................	(12)	....	33	165	28.
23.2E.29.332..	Las Cruces Ice Co.........	Aug. 13	....	....	....	....
26.3.9.221.....	Berino Cotton Gin.........	Aug. 12	148	....	142	45.
		Springs				
17.4.29.340...	Derry warm springs........	Apr. 17	....	....	52	19.
21.1.10.213...	Radium Springs............	May 17[5]	....	71	142	23.

[1]Analysts: C. S. Howard, E. F. Williams, V. E. Arnold, L. S. Hughes.
[2]Dec. 19, 1945.
[3]June 14, 1946.
[4]Dec. 9, 1936.
[5]1948.
[6]May 11, 1939
[7]Hydrant water at Pueblo Courts. City water supply being obtained from 3 city wells, 294, 296, and 301 feet deep.

of Sierra and Dona Ana Counties, N. Mex.

Parts per million except percent sodium and specific conductance]

Sodium and potassium (Na + K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as $CaCO_3$	Dissolved solids	Specific conductance (micromhos at 25 C)	Percent sodium

on mesa lands above valley floor

59	168	37	12	0.8	1.1	67	250	350	66
59	169	36	13	1.2	.8	70	219	360	64
74	180	58	11	1.0	1.1	66	283	385	71
....	180	....	11	....	....	....	....	357	....
73	180	52	13	1.2	1.3	66	283	360	70
35	207	44	10	1.7	11.	133	....	....	32
144	187	211	25	4.3	2.7	108	550	594	74
47	215	65	14	1.2	2.1	165	296	495	38
25	228	33	6	.2	9.1	184	254	449	23
53	218	103	14	.3	7.3	198	383	478	37
259	295	615	400	.3	1.5	884	1,740	2,640	39
90	181	145	18	.7	8.6	139	472	648	59
962	506	286	1,510	....	2.3	753	3,280	5,760	74
96	347	279	98	.2	....	505	829	1,260	29
30	120	65	9	....	.6	114	205	349	36
69	174	90	90	.6	.3	214	411	719	41
94	232	227	153	.3	2.6	441	747	1,210	32
84	227	246	158	....	.7	482	770	1,260	27
....	177	90	66	....	....	210	....	660	....
63	180	126	76	....	.6	248	442	761	36
139	370	41	20	....	6.8	76	414	698	80
81	183	91	63	....	.7	157	381	657	53
355	423	210	282	....	....	191	1,120	....	80
300	492	121	42	7.9	18.	26	773	1,290	96
178	345	74	47	2.0	8.8	70	513	865	85
247	407	180	72	....	.75	87	729	....	86
240	365	195	69	1.5	1.2	101	731	1,180	84
132	188	156	50	....	9.1	108	479	....	73

of valley floor of Rio Grande

296	316	666	119	....	0.9	478	1,440	1,400	57
128	220	342	147	.4	2.5	468	896	1,380	37
86	213	193	71	.3	.1	288	561	897	39
140	354	399	153	.2	.8	618	1,100	1,650	33
85	237	179	56	.3	.3	276	538	858	40
142	337	376	108	.4	9.6	520	993	1,460	37
44	164	65	44	.4	.4	170	297	520	36
309	508	747	289	.1	4.7	934	1,950	2,740	42
52	188	98	120	.3	2.8	314	481	846	27
131	....	268	112	....	....	501	943	....	36
125	382	294	118	....	....	485	970	....	36
125	....	290	122	....	....	527	1,012	....	34
....	176	....	42	....	....	....	....	500	....
47	663	211	436	.1	.6	540	1,550	2,580	61

Springs—Continued

303	370	309	160	5.8	2.0	208	1,030	1,650	76
1,160	427	265	1,660	4.6	2.0	449	3,540	6,060	86

[8] Sayre, A N., and Livingston, Penn, Ground-water resources of the El Paso area, Tex., U. S. Geol. Survey Water-Supply Paper 919, p. 121. Date of collection, Apr. 22, 1936.
[9] Idem Date of collection, July 17, 1936.
[10] City water supply being obtained from 2 wells, 75 and 100 feet deep, of El Paso Electric Co. Date of collection, 1930. Analyzed by C. W. Botkin, chemist, State College, N. Mex.
[11] See note 10. Date of collection, 1934?
[12] See note 10. Date of collection, Nov. 26, 1935.

Table 8.—*Auger holes in 2 lines across Park Drain, Holt and Seale roads, Mesilla Valley, N. Mex.*

Hole location no.	Field no.[1]	Depth (feet)	Top of casing: Elevation[2]	Top of casing: Above land surface (feet)	Reference point (Top edge of Geological Survey washer)
24.2E.5.424	N 2,817 E	12.3	3,828.22	0	East side of 9th power pole east of Park Drain, north side of road, 1.2 ft northwest of well, elevation 3,828.83 ft.
24.2E.5.434	N 577 E	15	3,828.98	0.50	Northeast side of 2d power pole east of Park Drain, north side of road, 1.6 ft west of well, elevation 3,829.97 ft.
24.2E.5.441	N 1,501 E	8.5	3,824.27	0	East side of 5th power pole east of Park Drain, north side of road, 1.2 ft west of well, elevation 3,825.29 ft.
24.2E.8.114	N 1,783 W	10.5	3,828.38	.50	South side of 1st power pole east of State Highway 28, nortn side of road, 2 ft northeast of well, elevation 3,829.23 ft.
24.2E.8.121	N 960 W	14	3,828.08	1.00	West side of 4th power pole west of Park Drain, north side of road, 1.3 ft north of well, elevation 3,828.84 ft.
24.2E.8.122	N 358 W	9	3,823.33	0	West side of 2d power pole west of Park Drain, north side of road, 2 ft north of well, elevation 3,824.25 ft.
24.2E.8.211	N 74 W	11	3,823.65	0	West side of 1st power pole west of Park Drain, north side of road, 2 ft north of well, elevation 3,824.85 ft.
24.2E.9.333	S 1,583 W	11	3,820.90	0	Northwest side of 5th power pole west of Park Drain, north side of road, 1.5 ft south of well, elevation 3,821.76 ft.
24.2E.9.334	S 441 W	12	3,821.59	0	West side of 2d power pole west of Park Drain, north side of road, 1.5 ft northeast of well, elevation 3,822.71 ft.
24.2E.9.343	S 101 W	11.5	3,821.21	0	Northwest side of 1st power pole west of Park Drain, north side of road, 1.3 ft northeast of well, elevation 3,821.76 ft.
24.2E.9.434	S 2,335 E	9	3,819.32	0	East side of 2d power pole west of railroad, north side of road, 2 ft west of well, elevation 3,819.97 ft.
24.2E.16.121	S 152 E	13	3,821.87	1.50	West side of cottonwood tree, south side of road, 2 ft southeast of well, elevation 3,823.23 ft.
24.2E.16.122	S 565 E	12	3,821.98	0	Southwest side of catalpa tree, south side of road, 2 ft southeast of well, elevation 3,822.44 ft.
24.2E.16.211	S 1,067 E	11.5	3,821.42	0	(U. S. Bureau of Reclamation well 32)
24.2E.17.221	S 2,916 W	12	3,823.45	1.50	(U. S. Bureau of Reclamation well 33)

[1] Wells having numbers beginning with letter "N" are on the north (Seale) road; with letter "S" on the south (Holt) road. Figure indicates distance of the well, in feet, east (E) or west (W) from the Park Drain along the Seale and Holt roads.
[2] Above U. S. Bureau of Reclamation datum, which is 40 feet above mean sea level.

Table 9.—*Water levels in auger holes in 2 lines across Park drain, 1947–48, in feet below land surface*

Date		Field nos. of wells														
		N1783W	N960W	N358W	N74W	N577E	N1501E	N2817E	S2916W	S1583W	S441W	S101W	S152E	S565E	S1067E	S2335E
1947																
Feb.	14	12.02	11.80	8.50	9.14	13.09	7.93	11.15	9.68	9.53	11.12	11.13	10.33	11.78	10.63	8.43
	21	12.09	11.84	8.54	9.16	13.14	7.99	11.23	[1]9.07	9.64	11.17	11.16	10.36	11.83	[1]10.88	8.50
	28	12.14	11.89	8.55	9.14	13.15	8.05	11.29	[1]9.03	9.72	11.19	11.11	10.33	11.84	[1]10.89	8.55
Mar.	7	12.13	11.89	8.55	9.27	13.17	8.08	11.34	9.90	9.75	11.20	11.14	10.34	11.86	11.22	8.60
	14	12.20	11.93	8.58	9.18	13.20	8.13	11.40	10.00	9.82	11.24	11.15	10.37	11.88	11.26	8.67
	28	11.49	11.57	8.35	9.00	13.19	8.18	11.43	9.89	9.69	11.13	11.02	10.27	11.86	11.28	8.71
Apr.	11	10.77	11.10	7.97	8.54	12.30	7.25	10.53	9.18	8.91	10.40	10.46	9.71	11.17	10.56	7.24
	24	10.34	10.52	7.63	8.34	12.19	7.02	10.29	8.56	8.58	10.21	10.29	8.47	10.89	10.02	6.42
May	9	10.07	10.32	7.52	7.45	12.05	6.87	10.16	8.40	8.41	10.12	10.35	9.41	10.72	9.84	6.51
	23	10.25	10.48	7.60	8.46	12.02	6.79	10.06	8.02	8.19	10.02	10.28	9.20	10.24	9.19	[1]5.37
June	6	10.23	10.48	7.62	8.52	12.04	6.77	10.05	7.80	8.02	10.01	10.36	9.31	10.33	9.17	5.44
	19	9.96	10.38	7.49	8.39	11.79	6.66	9.88	7.65	6.93	9.73	10.10	8.90	9.91	8.64	4.61
July	3	9.48	9.84	7.24	8.29	11.54	6.11	9.30	7.13	7.49	9.84	10.37	9.47	10.55	9.50	5.90
	17	9.28	9.91	7.18	8.11	11.27	5.66	8.53	6.79	7.37	9.45	9.96	8.72	9.66	8.79	4.50
Aug.	1	8.68	9.42	6.78	7.84	10.82	5.25	8.32	6.47	6.73	9.09	9.70	8.57	9.45	8.45	4.72
	15	8.41	9.29	6.65	7.74	10.26	4.68	7.83	5.36	6.11	8.86	9.66	8.68	9.54	8.57	5.46
	29	8.82	9.36	6.71	7.78	10.65	5.00	8.22	6.28	6.54	9.17	9.87	8.85	9.70	8.41	4.73
Sept.	12	9.02	9.60	6.90	7.90	11.09	5.57	8.75	5.55	6.20	8.98	9.85	8.90	9.79	8.60	5.40
	28	9.40	9.84	7.04	8.01	10.79	5.46	8.62	6.61	6.94	9.48	10.11	9.20	10.27	9.24	5.95
Oct.	10	9.70	10.07	7.23	8.17	11.44	5.95	9.19	....	7.31	9.75	10.29	9.39	10.56	9.59	6.59
	24	10.16	10.37	7.44	8.40	11.75	6.29	9.55	[2]7.15	7.80	10.01	10.45	9.58	10.80	9.94	7.07
Nov.	7	10.49	10.61	7.62	8.49	12.01	6.60	9.80	....	7.84	9.78	[1]10.52	9.70	10.98	10.16	7.19
	21	10.71	10.81	7.62	8.56	12.20	6.86	10.05	7.89	8.27	10.29	[1]10.59	9.75	11.02	10.11	[1]5.47
Dec.	5	10.94	10.96	7.82	8.67	12.24	7.09	10.29	8.16	8.37	10.37	10.62	9.59	10.90	9.98	7.15
	19	11.18	11.01	7.98	8.71	12.50	7.26	10.51	8.55	8.66	10.56	10.74	9.69	11.16	10.40	7.67
1948																
Jan.	2	11.31	11.22	8.05	8.78	12.63	7.42	10.69	8.88	8.89	10.70	10.76	9.80	11.34	10.61	7.94
	16	11.52	11.36	8.14	8.87	12.74	7.56	10.85	9.10	9.10	10.68	11.39	9.88	11.47	10.79	8.15
	30	11.70	12.51	8.22	8.91	12.81	7.71	11.00	9.44	9.30	10.97	[1]10.39	9.91	11.55	10.92	8.32
Feb.	13	....	11.61	8.30	....	12.90	7.85	11.13	9.67	9.48	11.05	11.03	10.10	11.70	11.04	8.47
	27	11.73	11.70	8.46	....	12.99	7.97	11.27	9.91	9.77	10.99	11.06	10.03	11.71	11.10	8.57

Table 9.—*Water levels in auger holes in 2 lines across Park drain, 1947–48, in feet below land surface*—Continued

Date		Field nos. of wells														
		N1783W	N960W	N358W	N74W	N577E	N1501E	N2817E	S2916W	S1583W	S441W	S101W	S152E	S565E	S1067E	S2335E
1948–Continued																
Mar.	12	Dry	11.79	8.45	Dry	13.04	8.07	11.43	10.14	9.84	11.20	10.97	10.12	11.74	11.16	8.72
	26	Dry	11.91	8.47	Dry	13.04	7.88	11.49	10.15	9.88	11.22	11.05	9.77	11.50	11.15	8.73
Apr.	9	11.18	10.90	7.70	Dry	11.54	6.63	10.34	9.51	9.44	10.62	10.44	9.83	11.28	10.80	8.61

[1]Measurement uncertain.
[2]Estimated.

Table 10.—*Water levels, in feet below land-surface datum, in auger well 23.2E.29.214*

[Measured at 5:00 p.m., 1947-48]

Location: Northeast corner of westernmost weather instruments shelter of New Mexico College of Agriculture and Mechanic Arts, State College, N. Mex.
Diameter: 2 inches; depth: 11 feet.
Measuring point: Top edge of hole in cap on casing, 5.22 feet below B. M. 102 U. S. C. and G. S. (3,844 feet above mean sea level), 0.25 foot above land-surface datum.
Reference point: Surface of northeast corner of concrete curbing for weather instruments shelter, 1.5 feet from well, 0.74 foot above land-surface datum.

Date	Water level	Date	Water level	Date	Water level	Date	Water level
1947		1947		1947		1947	
Feb. 19	10.07	May 8	9.69	July 6	9.07	Sept. 3	9.06
20	10.06	9	9.58	7	9.11	4	9.08
21	10.09	10	9.51	8	9.13	5	9.07
22	10.09	11	9.49	9	9.17	6	9.02
23	10.08	12	9.49	10	9.19	7	9.00
24	10.08	13	9.52	11	9.19	8	8.22
25	10.09	14	9.53	12	9.19	9	8.48
26	10.08	15	9.54	13	9.15	10	8.58
27	10.09	16	9.45	14	9.14	11	8.54
28	10.08	17	9.53	15	9.10	12	8.64
Mar. 1	10.06	18	9.55	16	9.05	13	8.68
2	10.05	19	9.59	17	9.10	14	8.58
3	10.04	20	9.60	18	9.15	15	8.51
4	10.03	21	9.63	19	9.15	16	8.51
5	10.05	22	9.60	20	9.06	17	8.47
6	10.07	23	9.63	21	9.02	18	8.49
7	10.08	24	9.53	22	9.05	19	8.63
8	10.09	25	9.55	23	9.10	20	8.67
9	10.09	26	9.55	24	9.11	21	8.69
10	10.10	27	9.55	25	9.05	22	8.73
11	10.10	28	9.56	26	9.01	23	8.76
12	10.10	29	9.61	27	8.94	24	8.80
13	10.11	30	9.43	28	8.95	25	8.84
14	10.12	31	8.64	29	8.97	26	8.87
15	10.12	June 1	9.03	30	9.01	27	8.90
16	10.13	2	9.12	31	8.80	28	8.93
17	10.14	3	9.23	Aug. 1	8.50	29	8.95
18	10.15	4	9.25	2	8.50	30	8.97
19	10.15	5	9.34	3	8.71	Oct. 1	8.99
20	10.15	6	9.35	4	8.79	2	9.00
21	10.15	7	9.35	5	8.85	3	9.05
22	10.15	8	9.33	6	8.90	4	9.05
23	10.15	9	9.31	7	8.92	5	9.07
24	10.15	10	9.33	8	8.91	6	9.11
25	10.15	11	9.33	9	8.89	7	9.12
26	10.16	12	9.33	10	8.89	8	9.15
27	10.17	13	9.29	11	8.90	9	9.18
28	10.16	14	9.23	12	8.94	10	9.18
29	10.15	15	9.25	13	8.95	11	9.21
30	10.13	16	9.23	14	8.95	12	9.23
31	10.11	17	9.31	15	8.95	13	9.25
Apr. 1	10.02	18	9.27	16	8.86	14	9.29
2	10.00	19	9.21	17	8.80	15	9.25
3	10.00	20	9.15	18	8.74	16	9.25
4	10.03	21	9.15	19	8.72	17	9.29
5	10.06	22	9.15	20	8.73	18	9.33
25	9.72	23	9.21	21	8.76	19	9.35
26	9.55	24	9.23	22	8.79	20	9.38
27	9.20	25	9.25	23	8.80	21	9.39
28	9.30	26	9.23	24	8.83	22	9.39
29	9.44	27	8.13	25	8.87	23	9.44
30	9.47	28	8.61	26	8.88	24	9.49
May 1	9.52	29	8.75	27	8.92	25	9.49
2	9.56	30	8.81	28	8.95	26	9.50
3	9.59	July 1	8.95	29	8.96	27	9.50
4	9.62	2	9.03	30	8.98	28	9.45
5	9.62	3	8.99	31	9.00	29	9.41
6	9.62	4	9.11	Sept. 1	9.02	30	9.46
7	9.67	5	9.11	2	9.03	31	9.51

Table 10.—*Water levels, in feet below land-surface datum, in auger well 23.2E.29.214*—Continued

Date	Water level	Date	Water level	Date	Water level	Date	Water level
1947		1947		1948		1948	
Nov. 1	9.54	Dec. 11	9.86	Jan. 20	10.09	Apr. 5	10.04
2	9.55	12	9.88	21	10.10	12	10.05
3	9.56	13	9.90	22	10.11	19	9.91
4	9.58	14	9.90	23	10.12	26	9.75
5	9.61	15	9.90	24	10.13	May 3	9.65
6	9.61	16	9.91	25	10.13	10	9.55
7	9.62	17	9.92	26	10.13	17	9.55
8	9.63	18	9.92	Feb. 10	10.17	24	9.60
9	9.64	19	9.92	11	10.17	31	9.85
10	9.64	20	9.94	12	10.17	June 7	9.85
11	9.65	21	9.92	13	10.18	14	9.95
12	9.65	22	9.95	14	10.20	21	9.75
13	9.66	23	9.95	15	10.21	28	9.95
14	9.68	24	9.94	16	10.21	July 5	9.99
15	9.70	25	9.95	17	10.21	12	9.89
16	9.69	26	9.96	18	10.22	19	9.91
17	9.69	27	9.96	19	10.23	26	10.03
18	9.70	28	9.97	20	10.23	Aug. 2	9.94
19	9.71	29	9.97	21	10.24	9	9.85
20	9.72	30	9.97	22	10.25	16	9.73
21	9.73	31	9.99	23	10.25	23	9.84
22	9.75	1948		24	10.26	30	9.71
23	9.75	Jan. 1	9.99	25	10.26	Sept. 6	9.75
24	9.75	2	9.99	26	10.25	13	9.75
25	9.76	4	10.00	27	10.25	20	9.78
26	9.76	5	10.00	28	10.15	27	9.76
27	9.77	6	10.01	29	10.05	Oct. 4	9.88
28	9.78	7	10.01	Mar. 1	10.15	11	9.90
29	9.79	8	10.01	2	10.15	18	9.85
30	9.79	9	10.02	3	10.23	25	9.89
Dec. 1	9.80	10	10.04	4	10.25	Nov. 1	9.98
2	9.81	11	10.04	5	10.26	8	9.99
3	9.83	12	10.04	6	10.27	15	10.00
4	9.84	13	10.05	7	10.27	22	10.04
5	9.84	14	10.06	8	10.28	29	10.03
6	9.84	15	10.06	9	10.28	Dec. 6	10.06
7	9.84	16	10.07	15	10.32	13	10.10
8	9.84	17	10.08	22	10.35	20	10.11
9	9.85	18	10.09	29	10.35	27	10.14
10	9.87	19	10.09				

Table 11.—*Water levels in wells in Rincon and Mesilla Valleys, N. Mex., 1946–48, in feet below land-surface datum*

Date	Location no. and owner					
	16.5.25.211	16.5.25.343	17.4.30.133a	17.4.31.111	17.4.32.112	17.5.10.442
	U. S. Bureau of Reclamation	Arley Osborn	W. B. Cantrell	Ben Luchini	Ray Painter	Arley Osborn
1946						
Nov. 22	19.29	33.13	...	...	...	...
Dec. 18	19.59	33.28	...	...	...	...
1947						
Jan. 8	19.44	33.34	...	...	...	...
Feb. 20	16.80	33.36	...	8.88	7.72	...
Apr. 17	11.30	33.28	13.32	5.83	[1]6.40	15.94
May 27, 28	12.44	32.60	12.37	5.79	7.01	15.32
July 3	13.61	32.35	11.89	5.13	6.35	16.85
Aug. 1	15.23	32.61	11.05	4.81	6.75	17.17
Aug. 30	16.68	32.67	11.29	5.48	6.63	[2]16.55
Sept. 27	17.83	32.86	11.52	7.17	6.85	16.84
Oct. 25	18.63	33.28	13.19	7.95	7.26	16.47
Dec. 2	19.46	33.71	14.45	8.51	7.39	15.66
1948						
Feb. 9, 14	19.43	34.21	15.48	9.09	...	15.36
Mar. 22	20.92	34.27	...	...	...	15.25

Table 11.—*Water levels in wells in Rincon and Mesilla Valleys, N. Mex., 1946–48, in feet below land-surface datum*—**Continued**

Date	Location no. and owner					
	17.5.14.212	17.5.14.231	17.5.24.333	17.5.26.212	17.5.26.242	19.3.4.331
	Arley Osborn	Felix Lara	E. W. Powers	Mickey Plemmons	Lloyd Welch	B. S. Thurman
1946						
Nov. 22, 23	...	58.73	28.23	...	...	6.25
Dec. 18	...	58.85	[3]28.64	...	...	...
1947						
Jan. 8	...	58.96	[3]28.92	...	...	...
Feb. 20	...	59.17	[3]29.40	...	...	6.70
Mar. 3	58.45	...	...	...	...	...
Apr. 17	60.76	59.37	...	43.99	36.60	4.93
May 27, 28	[4]79.80	59.24	28.48	43.65	35.94	5.15
July 3	60.04	59.15	28.29	42.64	35.90	[4]11.45
Aug. 1	60.00	59.15	28.02	43.50	35.77	5.30
Aug. 30	59.88	59.07	27.98	42.94	[4]43.87	...
Sept. 27	60.43	59.04	27.90	42.97	35.32	...
Oct. 25	61.22	59.24	28.54	43.37	35.71	...
Dec. 2	61.79	59.48	29.45	44.11	36.42	...
1948						
Feb. 14	62.62	59.83	30.46	45.11	37.40	...
Mar. 22	...	60.02	30.51	...	37.57	...

Table 11.—*Water levels in wells in Rincon and Mesilla Valleys, N. Mex., 1946–48, in feet below land-surface datum*—Continued

Date	Location no. and owner				
	19.3.4.331a	19.4.11.211	23.2E.29.143	23.2E.29.243b	23.2E.29.243c
	B. S. Thurman	Clyde Cowan	New Mexico A. & M. College	New Mexico A. & M. College	New Mexico A. & M. College
1946					
Nov. 14, 22, 23	6.25	11.92	12.82	......	......
Dec. 14, 18	......	12.28	13.17	34.00	......
1947					
Jan. 14	......	......	13.37	......	......
Feb. 15, 20	6.70	12.97	13.53	34.38	30.35
Mar. 7	......	......	[3]13.54	......	......
Apr. 16, 17	4.86	[4]20.54	13.20	34.34	30.24
May 23, 26, 27	5.02	[3]13.80	12.84	34.10	30.11
July 3	[5]6.22	......	12.93	33.55	29.70
Aug. 1	5.17	[4]12.58	[4]23.04	33.39	31.04
Aug. 30	4.92	10.69	12.96	33.23	29.39
Sept. 27, 29	5.73	11.32	12.34	33.22	30.92
Oct. 25	6.58	12.04	13.08	33.74	29.89
Dec. 2, 3	6.96	12.50	13.38	34.18	30.38
1948					
Feb. 10, 14	7.20	13.25	13.55	34.54	30.63
Mar. 25	......	......	13.63	[5]34.81	[5]32.47

[1] Nearby field irrigated recently.
[2] New measuring point, not exactly correlated with previous one.
[3] Well had been pumped.
[4] Well being pumped.
[5] Nearby well being pumped.

Table 12.—*Records of large-diameter wells near or on the valley floor of the Rio Grande in Rincon and Mesilla Valleys*

Sheet and tract: letters and numbers refer to Irrigable area and property maps of Elephant Butte Irrigation District, U S. Bureau of Reclamation—Rio Grande project.
Owner or name: NMAC refers to New Mexico College of Agriculture and Mechanic Arts.
Topographic situation: A, arroyo bed; F, valley floor; M, mesa surface; S, alluvial side slope or arroyo slope.
Altitude: A, determined by aneroid; T, determined from U. S. Geological Survey topographic quadrangle maps.
Type of well: Dd, dug and drilled; Dr, drilled; Du, dug; J, jetted.
Depth of well: reported.
Water level: reported figures given to nearest foot.
Type of pump: AL, air lift; C, centrifugal; Pl, plunger; T, turbine.
Kind of power: B, butane engine; D, diesel engine; E, electric motor; G, gasoline engine;T, tractor engine; W, wind.
Discharge rate: E, estimated; M, measured;. R, reported.
Drawdown: E, estimated; M, measured; R, reported.
Use of water: A, abandoned; D, domestic; I, irrigation; II, intended irrigation; M, municipal, RR, railroads; S, stock; U, unused, equipped with pump.

Table 12.—*Records of large-diameter wells near or on the valley*

No.	Well location no.	Sheet	Tract	Owner or name	Driller	Date completed	Topographic situation
Rincon Valley, Sierra							
1	16.5.23.300	....	....	O. B. Dawson......	Mickey Plemmons..	April 1947..	S
2	16.5.25.120	A	....	U. S. Bureau of Reclamation.	George Cook........	1936.........	A
3	16.5.25.211	A	....	.........do..........	....	.......do......	A
4	16.5.25.341	A	....	A. J. Osborn......	Mickey Plemmons..	July 1947....	S
5	16.5.25.343	A	....	.........do..........	George Cook........	March 1946	S
6	17.4.30.133a	C	22	W. B. Cantrell....	Toby Tipton.........	March 1947	F
7	17.4.31.111	C	48	Ben Luchini.........	...........do..........	December.. 1946.	F
8	17.4.32.112	C	37	Ray Painter.........	Mickey Plemmons..	February..... 1947.	F
9	17.5.10.442	B	....	A. J. Osborn......	...........do..........	......do......	M
10	17.5.14.212	B	....	...........do..........	...........do..........	March 1947	S
11	17.5.14.231	B	....	Felix Lara...........	Harrison.............	1946..........	A
12	17.5.14.441	B	53B	Earl Riggs...........	Mickey Plemmons..	July 1947....	S
13	17.5.23.442	C	....	Marsella Fritz......	...........do..........	1934 (?).....	S
14	17.5.23.442a	C	....	...........do..........	Marsella Fritz.......	February.... 1948.	S
15	17.5.24.331	C	....	Tod Robison........	Harliss................	1934..........	S
16	17.5.24.333	C	....	E. W. Powers......	George Cook........	April 1946..	S
17	17.5.25.123	C	25	G. P. Black........	Mickey Plemmons..	October...... 1947.	F
18	17.5.25.134	C	25	.........do..........	...........do..........	......do......	F
19	17.5.26.212	C	....	Mickey Plemmons.	..........do..........	March 1947	S
20	17.5.26.242	C	....	Lloyd Welch.......	..........do...........	February..... 1947.	S

No.	Well location no.	Pump			Yield		Drawdown below static level	
		Type	Size (in.)	Kind of power	Rate (gpm)	Date of measurement	Amount	Duration of test (hr)
Rincon Valley, Sierra								
1	16.5.23.300	T	8	G	850 M	June 5, 1947....	115.00 M	4
2	16.5.25.120	AL	....	G	13 R	1936.............	21 R	48
3	16.5.25.211	None	None	None	....	....	....	....
4	16.5.25.341	None	None	None	125 R	July 14, 1947...	100 (?) R	2
5	16.5.25.343	T	6	G	250 E	July 15, 1947...	....	....
6	17.4.30.133a	T	8	T	....	....	....	....
7	17.4.31.111	T	10	B	1,000 M	July 18, 1947...	14.2 M	9
8	17.4.32.112	T	6	G	800 R	February 1947...	14 R	4
9	17.5.10.442	None	None	None	....	....	....	....
10	17.5.14.212	T	6	G	250 E	July 23, 1947...	22.6 M	6
11	17.5.14.231	None	None	None	500 R	1946.............	....	....
12	17.5.14.441	C	4	E	800 R	July 1947........	19 R	10
13	17.5.23.442	C	4	G	250-300 E	Aug. 1, 1947...	10 R	4
14	17.5.23.442a	T	....	....	....	....	....	....
15	17.5.24.331	C	6	T	450 E	Aug. 1, 1947...	12 R	5
16	17.5.24.333	T	8	G	650 M	July 25, 1947...	20.5 M	5
17	17.5.25.123	T	8	G	860 M	Dec. 2, 1947...	....	40
18	17.5.25.134	T	8	T	780 M	.........do.........	....	3
19	17.5.26.212	T	6	G	225 M	June 4, 1947....	20.00 M	2
20	17.5.26.242	T	8	G	700 G	July 24, 1947...	8.5 M	8

floor of the Rio Grande in Rincon and Mesilla Valleys—Continued

Altitude above sea level (ft)	Type of well	Depth of well (ft)	Diameter of well (in.)	Principal water-bearing bed: Depth to top of bed (ft)	Thickness (ft)	Character of material	Depth to which well is cased (ft)	Water level: Below land surface (ft)	Date of measurement
County, N. Mex.									
4,280 A	Dr	226	18	186	12	Gravel...........	215	Flows	June 5, 1947
4,194 T	Dr	138	6	....	....	....	107	24.12	Nov. 22, 1946
4,181 T	Dr	32	10	....	....	....	....	19.29	Do.
4,180 T	Dr	127	10	....	....	....	127	27.20	July 3, 1947
4,182 T	Dr	152	12	38	....	....	131	32.22	June 21, 1946
4,140 T	Dr	97	18	12	43	Sand and gravel..	69	13.32	Apr. 17, 1947
4,113 T	Dr	71	14	10	43	.........do.......	65	8.88	Feb. 20, 1947
4,110 T	Dr	80	12	....	....	....	80	7.72	Do.
4,260 A	Dr	207	15±	....	....	....	None	15.94	Apr. 17, 1947
4,188 T	Dr	121	10	....	....	....	121	58.45	Mar. 3, 1947
4,180 T	Dr	100(?)	12	....	....	....	....	58.73	Nov. 22, 1946
4,140 T	Dd	80	12	....	....	....	80(?)	13.90	Aug. 1, 1947
4,140 T	Dd	65	6	....	....	....	....	....	....
4,140 T	Dr	....	....	....	....	....	....	....	....
4,140 T	Dd	74	14	....	....	....	74	28.	Aug. 1, 1947
4,140 T	Dr	101	12	55	18	Sand and gravel.	....	28.23	Nov. 23, 1946
4,120 T	Dr	59	18	....	....	.........do.......	....	14.65	Feb. 14, 1948
4,120 T	Dr	64	18	....	....	.........do.......	....	12.77	Do.
4,160 T	Dd	68	10	....	....	.........do.......	68	43.99	Apr. 17, 1947
4,152 T	Dr	85	12	57	27	Gravel...........	85	36.60	Do.

Specific capacity (gpm/ft)	Use of water	Measuring point: Description	Height above (+) or below (-) land-surface datum (ft)	Remarks
County, N. Mex.—Continued				
63	I	Top of casing............	0.00	Temperature 75 F. Artesian flow 125 gpm estimated June 5, 1947. See analysis.
0.6	D	Bottom of air-line elbow	+4.00	See analysis.
....	A	Top of casing............	+3.00	Used during construction of Caballo Dam.
1.2	II	............do............	+.60	Quantity insufficient for irrigation.
....	I	............do............	+.25	Depth 131 ft measured July 1947.
....	II	............do............	+4.00	
70	I	Top west edge of 3-in.. pipe in concrete.	+.83	Temperature 67 F.
57	II	Top of extended casing	+.85	
....	A	Land surface............	+.00	Water level can be lowered to 70 ft by bailer.
11	I	Top of casing...........	+.30	Temperature 69 F. See analysis.
....	II	............do............	+1.38	
42	I	Land surface............	.00	Dug 18 ft. Test pumped at date of completion.
25	I	....	....	Temperature 67 F. Diameter of pit 72 in.
....	I	....	....	About 10 ft west of well 17.5.23.442.
38	I	Bottom of N-S 8x8 in.. pump support, east side of well.	.00	Temperature 67 F. Diameter of pit 72 in.
32	I	Top of casing...........	+.50	Temperature 67 F. See analysis.
....	I	............do............	.00	
....	I	............do............	1.00	Temperature 64 F.
11	I	Bottom of pump base... flange.	+1.00	Temperature 67 F. Diameter of pit 60 in. See analysis.
82	I	Top of casing...........	+.50	Temperature 67 F.

Table 12.—*Records of large-diameter wells near or on the valley*

No.	Well location no.	Sheet	Tract	Owner or name	Driller	Date completed	Topo-graphic situation
						Rincon Valley, Dona Ana	
21	18.4.5.214	D	1B	W. A. Prater......	....	1946..........	F
22	18.4.17.312	D	145	W. B. Engler.......	Toby Tipton.........	July 1947....	F
23	18.4.17.411	D	144C	Fred Riggs..........	Mickey Plemmons	December... 1947.	F
24	18.4.35.231	E	120	A. A. Franzoy......	Toby Tipton.........	August 1947	F
25	19.2.3.122	......	....	A. T. & S. F. Ry...	P. D. Wynne........	January 1932	S
26	19.3.4.331	G	....	B. S. Thurman.....	Mickey Plemmons..	July 1946....	F
27	19.3.4.331a	G	....	..........do..........	..........do..........	1946..........	F
28	19.3.5.	G	....	..........do..........	Marsella Fritz........	January 1948	F
29	19.3.9.121	G	10	Village of Hatch...	....	1933..........	F
30	19.3.9.121a	G	10	..........do..........	Claude Kight........	July 1947....	F
31	19.3.10.333	G	113	E. L. Cocks........	Mickey Plemmons..	........do.....	F
32	19.3.10.432	G	89	Lee Stotts..........	..........do...........	August 1947	F
33	19.3.15.443	G	169B	I. W. Smallwood..	Toby Tipton.........	February..... 1947.	F
34	19.4.3.234	F	....	D. L. Oliver........	Claude Kight........	June 1947....	S
35	19.4.11.221	F	73	Clyde Cowan.......	Mickey Plemmons..	October 1946	S
						Mesilla Valley, Dona	
36	21.1E.30.323	2	11	B. W. Vermillon...	....	Mar. 1948...	F
37	21.1E.31.322	2	23	Rudolph Garcia....	....	Jan. 1948....	F
38	21.1E.31.412	2	22	Edgar Rhodes.......	Morrison Bros.......	......do.......	F
39	21.1.11.431	1	....	C. C. Rice.........	Jack Daniels........	Mar. 1948...	M

No.	Well location no.	Pump			Yield		Drawdown below static level	
		Type	Size (in.)	Kind of power	Rate (gpm)	Date of measurement	Amount	Duration of test (hr)
							Rincon Valley, Dona Ana	
21	18.4.5.214	C	3	G	280 R	....	....	....
22	18.4.17.312	T	6	T	....	....	....	....
23	18.4.17.411	C	6	G	....	....	....	....
24	18.4.35.231	T	8	G	1,000 R	....	....	....
25	19.2.3.122	T	....	E	225 R	January 1932......	14 R	....
26	19.3.4.331	T	6	G	660 M	Apr. 18, 1947....	8.9	96
27	19.3.4.331a	None	None	None	400 R	1946...............	....	....
28	19.3.5	....	....	....	....	....	....	....
29	19.3.9.121	None	None	None	120 R	....	....	....
30	19.3.9.121a	C	1¼	E	150 E	Aug. 1, 1947.....	2.1 M	⅓
31	19.3.10.333	T	10	G	600 E	Aug. 11, 1947....	10.0 M	¼
32	19.3.10.432	T	10	G	700 E	Aug. 15, 1947....	10.4 M	3
33	19.3.15.443	T	8	T	250 E	Apr. 17, 1947....	....	....
34	19.4.3.234	C	6	T	500 R	June 1947..........	5 R	8
35	19.4.11.221	T	8	T	700 M	July 24, 1947.....	12 M	4
							Mesilla Valley, Dona Ana	
36	21.1E.30.323	T	8	G	1,000 R	....	....	....
37	21.1E.31.322	T	8	T	1,200 R	....	11 R	....
38	21.1E.31.412	....	....	....	1,000 R	....	30 R	....
39	21.1.11.431	T	8	D	....	....	....	....

floor of the Rio Grande in Rincon and Mesilla Valleys—Continued

Altitude above sea level (ft)	Type of well	Depth of well (ft)	Diameter of well (in.)	Principal water-bearing bed: Depth to top of bed (ft)	Principal water-bearing bed: Thickness (ft)	Principal water-bearing bed: Character of material	Depth to which well is cased (ft)	Water level: Below land surface (ft)	Water level: Date of measurement
County, N. Mex.									
4,107 T	Du	20	....	....	....	....	....	13.40	Feb. 14, 1948
4,095 T	Dr	70	12	5	60	Sand and gravel	70	5.34	Aug. 11, 1947
								9.65	Feb. 14, 1948
4,092 T	Dr	70	12	....	....	....	....	8.3	Dec. 2, 1947
4,070 T	Dr	68	12	10	38	Sand and gravel	60	6.92	Aug. 15, 1947
....	Dr	260	14	....	....	....	260	120.	January 1932
4,052 T	Dr	52	10	....	....	Sand and gravel.	52	6.25	Nov. 22, 1946
4,052 T	Dr	35	12	....	....	....	35	6.25	Do.
....	.....	....	....	....	....	....	....	....	....
4,050 T	Dr	32	8	....	....	Fine sand........	32	3.38	Aug. 1, 1947
4,050 T	Dr	70	7	53	15	Gravel...........	67	3.38	Do.
4,049 T	Dr	69	12	42	12	..........do.......	69	4.98	Aug. 11, 1947
								8.57	Feb. 14, 1948
4,049 T	Dr	68	12	....	....	Sand..............	68	9.13	Aug. 27, 1947
								11.71	Feb. 14, 1948
4,040 T	Dr	53	12	10	30	Sand and gravel.	53	5.65	Feb. 20, 1947
4,075 T	Dr	68	8	22	46	Fine sand........	68	8.49	June 12, 1947
4,080 T	Dr	74	10	16	54	Fine and coarse sand.	74	11.92	Nov. 23, 1946
Ana County, N. Mex.									
....	Dr.	....	14	....	....	....	....	9.42	Mar. 26, 1948
3,943 T	Dr	100	12	....	....	....	....	10.55	Feb. 12, 1948
3,945 T	Dr	77	16	50	25	Gravel...........	75	9.58	Do.
4,020 T	Dr	150	12	....	....	....	....	64.00	Mar. 26, 1948

Specific capacity (gpm/ft)	Use of water	Measuring point: Description	Measuring point: Height above (+) or below (-) land-surface datum (ft)	Remarks
County, N. Mex.—Continued				
....	I	Top of wooden cribbing.	+1.50	Pit, 5 by 9 ft.
....	I	Top of casing..........	+1.00	
....	I	Land surface...........	.00	Water level measured while being drilled.
....	I	Top of casing..........	.00	
16	M, RR	....	....	Rincon domestic supply.
74	I	Top of casing.........	+2.00	Temperature 60 F. See analysis.
....	A	............do...........	+.37	78 ft from well 19.3.4.331.
....	I	....	....	
....	A	Top of casing.........	+.80	Well sanded.
71	M	............do...........	+.70	Temperature 62 F. Emergency use only. Two pumps. See analysis.
60	I	............do...........	.00	Temperature 65 F. See analysis.
67	I	............do...........	+1.00	Temperature 65 F. See analysis.
....	I	Top edge of casing....	+1.00	Temperature 63 F. Insufficient power.
100	I	Top of casing..........	-5.40	
58	I	............do...........	-.90	Temperature 66 F. See analysis.
County, N. Mex.—Continued				
....	I	Top of casing..........	+.75	
110	I	............do...........	+.50	
33	II	............do...........	+2.00	
....	I	............do...........	+1.25	See analysis.

Table 12.—*Records of large-diameter wells near or on the valley*

No.	Well location no.	Sheet	Tract	Owner or name	Driller	Date completed	Topo-graphic situation
						Mesilla Valley, Dona Ana	
40	21.1.13.323	1	7	Isaac Rhodes.......	Morrison Bros........	1948..........	F
41	21.1.14.433	1	4A1	Roy Black..........	....	....	F
42	22.1E.8.421	3	37	Carl Nakayama....	Jack Doherty.........	August....... 1947.	F
43	22.1E.8.421a	3	37	..........do...........	McBee................	October...... 1947.	F
44	22.1E.10.413	4	....	E. A. Knight........	Joe Clary.............	September.. 1947.	S
45	22.1E.15.343	4	37A	Clifford Hare.......	Morrison Bros........	December... 1947.	F
46	22.1E.15.431	4	40	Claude Tharp......	Joe Clary.............	September.. 1947.	F
47	22.1E.21.211	4	12B2	Rudolph Garcia....	....	1906..........	F
48	22.1E.22	4	35B(?)	..........do...........	....	November... 1947.	F
49	22.1E.26.214	5	21	J. K. Nakayama...	Joe Clary.............	August 1947.	F
50	22.1E.27.411	5	32	J. W. Taylor.......	Morrison Bros........	February..... 1948.	F
51	22.1E.28.142	4	63A	T. L. Simpson.....	....	November... 1947.	F
52	22.1E.33.321	5	89	K. H. Walker......	Jack Daniels.........	August 1947.	F
53	23.1E.1.414	7	68	R. L. Mayse	....	1948..........	F
54	23.1E.1.423	7	70	J. O. Gomez........	Jack Daniels.........	January...... 1948.	S
55	23.1E.1.443	9	2	L. B. Linbeck......	............do..........	September.. 1947.	F
56	23.1E.2.143	7	8A	Tatman.............	Morrison Bros........	March 1948.	F
57	23.1E.4.413	6	16	J. A. Griffin.......	............do..........	......do......	F
58	23.1E.9.411	8	1	Raymond Macaw..	............do..........	......do......	F
59	23.1E.10.442	7	56	Tsuyuko Yanaga...	McBee................	September.. 1947.	F

floor of the Rio Grande in Rincon and Mesilla Valleys—Continued

Altitude above sea level (ft)	Type of well	Depth of well (ft)	Diameter of well (in.)	Principal water-bearing bed: Depth to top of bed (ft)	Principal water-bearing bed: Thickness (ft)	Principal water-bearing bed: Character of material	Depth to which well is cased (ft)	Water level: Below land surface (ft)	Water level: Date of measurement
County, N. Mex.—Continued									
3,960 T	Dr	215	16	48	10	Gravel...........	....	12.4	Feb. 12, 1948
3,960 T	Dr	....	....	....	....	....	....	....	....
3,925 T	Dr	175(?)	14	....	....	....	80	8.30 8.46	Dec. 5, 1947 Feb. 12, 1948
3,925 T	Dr	....	16	....	....	....	....	12.23	Do.
3,945 T	Dr	132	12	40	22	Sand and........ gravel.	116	21.45	Sept. 11, 1947
3,925 T	Dr	108	16	....	....	.........do.........	....	11.87	Feb. 12, 1947
3,920 T	Dr	75	12	....	....	....	....	11.15 11.58	Dec. 5, 1947 Feb. 12, 1948
3,920 T	Dd	197	6	....	....	....	....	9.56 10.41	Dec. 5, 1947 Feb. 12, 1948
....	Dr	130	....	....	....	....	....	....	....
3,915 T	Dr	100	12	30	34	Sand and........ gravel.	93	15.	August 1947
3,920 T	Dr	107	16	48	59	.........do.........	107	....	....
3,920 T	Dr	80	16	55	25	Gravel...........	....	11.19 12.43	Dec. 5, 1947 Feb. 12, 1948
3,925 T	Dr	74	10	22	52	Sand and........ gravel.	74	14.64	Aug. 12, 1947
3,910 T	J	60	3	....	....	....	....	15.46	Feb. 12, 1948
3,915 T	Dr	100	14	....	....	....	....	21.27	Do.
3,905 T	Dr	75	12	....	....	....	....	17.08 17.53	Dec. 5, 1947 Feb. 12, 1948
....	Dr	....	14	....	....	....	....	....	....
....	Dr	90	14	....	....	....	....	....	....
....	Dr	90	14	....	....	....	....	....	....
3,900 T	Dr	95	16	50	15	Small gravel...	....	13.98 14.85	Dec. 5, 1947 Feb. 11, 1948

Table 12.—*Records of large-diameter wells near or on the valley*

No.	Well location no.	Pump			Yield		Drawdown below static level	
		Type	Size (in.)	Kind of power	Rate (gpm)	Date of measurement	Amount	Duration of test (hr)
Mesilla Valley, Dona Ana								
40	21.1.13.323	....	....	....	....	....	....	....
41	22.1.14.433	....	....	....	....	....	....	....
42	22.1E.8.421	T	10	G	900 E	Oct. 10, 1947....	26 M	10±
43	22.1E.8.421a	None	None	None	....	....	....	....
44	22.1E.10.413	T	8	T	....	....	....	....
45	22.1E.15.343	T	10	G	2,000 R	....	30 R	....
46	22.1E.15.431	T	8	T	800 R	....	....	....
47	22.1E.21.211	T	10	T	1,000 R	1947........	16 R	....
48	22.1E.22	None	None	None	....	....	....	....
49	22.1E.26.214	T	8	T	1,000 E	Aug. 29, 1947....	16 R	....
50	22.1E.27.411	T	....	....	....	....	....	....
51	22.1E.28.142	T	10	T	1,200 R	February 1948....	....	....
52	22.1E.33.321	T	8	T	800 R	1947........	30 M	....
53	23.1E.1.414	AL	....	....	Poor	....	....	....
54	23.1E.1.423	T	8	T	1,000 R	....	....	....
55	23.1E.1.443	T	6	T	600 R	....	....	....
56	23.1E.2.143	T	10	....	....	....	....	....
57	23.1E.4.413	....	....	....	....	....	....	....
58	23.1E.9.411	....	....	....	....	....	....	....
59	23.1E.10.442	T	8	T	1,200 R	....	....	....

floor of the Rio Grande in Rincon and Mesilla Valleys—Continued

Specific capacity (gpm/ft)	Use of water	Measuring point: Description	Measuring point: Height above (+) or below (-) land-surface datum (ft)	Remarks
County, N. Mex.—Continued				
....	II	....	....	Depth at time of water-level measurements.
....	II	....	....	
35	I	Top of casing..........	.00	Temperature 62 F.
....	II	..............do...........	+.50	About 120 feet north of well 22.1E.8.421.
....	I	..............do...........	+.40	Sand filled well when tested.
67	I	..............do...........	+1.50	
....	I	..............do...........	+1.25	
63	I	Base of pump..........	-1.00	Pit; diameter 18 ft, depth 30 ft. Old Shalem Colony well; see W.S.P. 188, p. 45.
....	II	....	....	
63	I	....	....	Temperature 63 F. See analysis.
....	II	....	....	Well sanded.
....	I	Top of casing..........	-1.00	Reportedly poor quality.
27	II	..............do...........	+2.85	See analysis.
....	II	..............do...........	+1.75	Two wells about 30 ft apart.
....	I	..............do...........	+1.00	
....	I	..............do...........	+.75	
....	I	....	....	
....	I	....	....	
....	I	....	....	
....	I	Top of casing..........	.00	

Table 12.—*Records of large-diameter wells near or on the valley*

No.	Well location no.	Sheet	Tract	Owner or name	Driller	Date completed	Topographic situation
						Mesilla Valley, Dona Ana	
60	23.1E.13.144	9A	157	Hadley Street well, Las Cruces.	Frank Dickinson.....	June 1947...	F
61	23.1E.13.244	9A	....	A. T. & S. F. Ry., well 2.	A. A. Riggs.........	November 1925.	F
62	23.1E.21.314	10	82A	O. McElyea.........	Jack Daniel..........	November 1947.	F
63	23.1E.21.314a	10	82A	..........do..........	............do..........	.......do......	F
64	23.1E.26.311	10	56	Victor Ginther......	Victor Ginther.......	1948..........	F
65	23.1E.35.231	10	64	Harry Tashiro.......	McBee................	August 1947	F
66	23.1E.35.421	10	64	Tashiko Tashiro....	............do..........	September... 1947.	F
67	23.1E.36.333	12	33A1	Stahman Farms Inc., well 2.	J. F. Williams......	November 1947.	F
68	23.2E.6.323	9 .	....	Las Cruces Country Club.	Andy Rominger......	1925 (?).....	M
69	23.2E.6.332	9 .	....	Mrs. Fay Sperry....	R. D. Sidey.........	March 1940.	M
70	23.2E.8.434	......	....	City of Las Cruces, well 5.	Frank Dickinson.....	May 1947....	M
71	23.2E.17.210	......	....	City of Las Cruces, well 1.	McCollough..........	1936 (?).....	M
72	23.2E.17.210a	......	....	City of Las Cruces, well 2.	....	....	M
73	23.2E.17.210b	......	....	City of Las Cruces, well 3.	Dickinson............ brothers.	November 1938.	M

No.	Well location no.	Pump			Yield		Drawdown below static level	
		Type	Size (in.)	Kind of power	Rate (gpm)	Date of measurement	Amount	Duration of test (hr)
							Mesilla Valley, Dona Ana	
60	23.1E.13.144	None	None	None	....	....	....	....
61	23.1E.13.244	C	2	E	230 R	November 1925...	9 R	....
					64 M	Nov. 16, 1946....	3.9 M	16
62	23.1E.21.314	T	8	G	1,200 R	....	....	....
63	23.1E.21.314a	T	10	G	1,500 R	....	....	....
64	23.1E.26.311	....	....	....	....	....	....	....
65	23.1E.35.231	T	8	G	1,100 R	....	....	....
66	23.1E.35.421	T	8	G	700 R	....	....	....
67	23.1E.36.333	T	10	G	1,000 R	....	65 (?)R	5
68	23.2E.6.323	T	4	E	150 R	....	13 R	24
69	23.2E.6.332	....	....	....	45 R	March 1940........	10 R	....
70	23.2E.8.434	T	6	E	250 E	May 13, 1947.....	12.6 M	96
71	23.2E.17.210	T	6	E	250 M	Apr. 3, 1947.....	....	....
72	23.2E.17.210a	T	6	E	205 M	..........do.........	10 (?)M	....
73	23.2E.17.210b	T	6	E	270 M	..........do.........	....	....

floor of the Rio Grande in Rincon and Mesilla Valleys— Continued

Altitude above sea level (ft)	Type of well	Depth of well (ft)	Diameter of well (in.)	Principal water-bearing bed: Depth to top of bed (ft)	Principal water-bearing bed: Thickness (ft)	Principal water-bearing bed: Character of material	Depth to which well is cased (ft)	Water level: Below land surface (ft)	Water level: Date of measurement
County, N. Mex.—Continued									
3,895 T	Dr	175	14	110	55	Sand and small gravel.	170	11.34	July 31, 1947
3,895 T	Dd	82	13	....	....	Sand and boulders.	87	15.	November 1925
								12.25	Nov. 13, 1946
3,898 T	Dr	90	12	....	....	....	....	10.87	Dec. 5, 1947
								11.63	Feb. 11, 1948
3,898 T	Dr	90	12	....	....	....	....	10.94	Dec. 5, 1947
								10.93	Feb. 11, 1948
3,880 T	Du	....	120	....	....	....	....	10 R	February 1948
3,878 T	Dr	80	16	....	....	....	74	10.68	Dec. 4, 1947
								11.50	Feb. 10, 1948
3,878 T	Dr	80	16	....	....	....	....	12.84	Dec. 4, 1947
								13.81	Feb. 10, 1948
3,878 T	Dr	99	14	....	....	....	....	13.43	Dec. 4, 1947
								14.30	Feb. 10, 1948
3,959 A	Dd	190	8	....	....	....	190	77.8	Apr. 10, 1947
3,950 T	Dr	133	8	....	....	....	133	65	March 1940
4,057 L	Dr	300	13	200	55	Sand and gravel.	285	185.09	Apr. 15, 1947
								189.28	Oct. 8, 1947
								186.71	Dec. 3, 1947
4,042 A	Dr	294	10	....	....	....	294	170.±	1936 (?)
4,050 A	Dr	296	10	....	....	....	296	192.12	May 14, 1947
4,048 A	Dr	301	10	....	....	Sand and gravel.	292	160.±	November 1938

Specific capacity (gpm/ft)	Use of water	Measuring point: Description	Measuring point: Height above (+) or below (-) land-surface datum (ft)	Remarks
County, N. Mex.—Continued				
....	M	Top of casing..........	+0.50	
26	RR	Top of valve...........	-11.51	Original depth 251 ft, backfilled to 82 ft for best water.
16				
....	I	Top of casing..........	.00	
....	I	..............do...........	+.50	200± ft east of well 23.1E.21.314.
....	II	....	....	
....	I	Top of casing..........	+.50	Reportedly poor quality.
....	I	..............do...........	+.25	Filled with sand to 70 (-) ft.
15	I	..............do...........	+1.00	
12	I	Top of 8 by 8 pump supports.	+.70	See analysis.
... 45	DI	....	....	Irrigates yard.
20	M	Top of casing..........	+.50	See analysis.
....	M	....	....	
20	M	Top of concrete floor.	.00	See analysis.
....	M	....	....	

Table 12.—*Records of large-diameter wells near or on the valley*

No.	Well location no.	Sheet	Tract	Owner or name	Driller	Date completed	Topographic situation
						Mesilla Valley,	Dona Ana
74	23.2E.17.210c	......	....	City of Las Cruces, well 4.	Dickinson brothers..	1940 (?)......	M
75	23.2E.17.210d	....	....	City of Las Cruces, well 6.	Frank Dickinson.....	November... 1947.	M
76	23.2E.20.412	11	....	B. B. Evans.........	Dutch Chandler.....	1937..........	S
77	23.2E.28.113	11	....	NMAC, domestic... well 1.	....	1906.........	S
78	23.2E.29.143	11	59	NMAC, Irrig. Eng.. well 3.	R. D. Sidey.........	June 1935....	F
79	23.2E.29.243	11	....	NMAC, domestic... well 2	....	1932 (?)......	S
80	23.2E.29.243a	11	....	NMAC, domestic... well 3.	Dickinson brothers..	1938..........	S
81	23.2E.29.243b	11	....	NMAC...............	...........do..........	November.... 1946.	S
82	23.2E.29.243c	11	....	NMAC, domestic... well 4.	.... do..........	February...... 1947.	S

No.	Well location no.	Pump			Yield		Drawdown below static level	
		Type	Size (in.)	Kind of power	Rate (gpm)	Date of measurement	Amount	Duration of test (hr)
						Mesilla Valley,	Dona Ana	
74	23.2E.17.210c	T	6	E	310 M	Apr. 3, 1947.....	....	....
75	23.2E.17.210d	T	6	E	290 M	Feb. 12, 1948....	....	....
76	23.2E.20.412	C	6	E	200 R	1937...............	.... 3 R	....
77	23.2E.28.113	Pl	....	E	100 R	1946...............	16 R	....
78	23.2E.29.143	T	8	E	1,270 M	Nov. 18, 1946...	13 M	24
79	23.2E.29.243	Pl	....	E	100 R	1946...............	....	....
80	23.2E.29.243a	Pl	....	E	100 R	.........do.........	....	....
81	23.2E.29.243b	None	None	None	....	....	....	....
82	23.2E.29.243c	None	None	None	....	....	....	....

floor of the Rio Grande in Rincon and Mesilla Valleys—Continued

Altitude above sea level (ft)	Type of well	Depth of well (ft)	Diameter of well (in.)	Principal water-bearing bed: Depth to top of bed (ft)	Principal water-bearing bed: Thickness (ft)	Principal water-bearing bed: Character of material	Depth to which well is cased (ft)	Water level: Below land surface (ft)	Water level: Date of measurement
County, N. Mex.—Continued									
4,048 A	Dr	298	10	......	......	......	298	......	......
......	Dr	300±(?)	12	......	......	......	......	184.54	Dec. 3, 1947
								184.91	Feb. 12, 1948
								184.90	Mar. 25, 1948
3,935 A	Dd	70	12	50	20	Gravel......	70	56	April 1947
3,942 T	Dd	110	12	......	......	......	110	75	1946
3,883 L	Dr	50	16	......	......	Sand and gravel.	50	12.82	Nov. 14, 1946
3,899 T	Dd	228	4	......	......	......	228	28	1932
3,906 T	Dd	428	8	......	......	......	......	35	1938
3,903 L	Dr	83	18	55	20	Sand and large gravel.	81	34.00	Dec. 14, 1946
3,898 L	Dr	305	14	......	......	......	286	30.35	Feb. 15, 1947

Specific capacity (gpm/ft)	Use of water	Measuring point: Description	Measuring point: Height above (+) or below (-) land-surface datum (ft)	Remarks
County, N. Mex.—Continued				
......	M	......	......	
......	M	Edge of 3-in. sloping pipe in concrete base.	+.82	
67	I	......	......	Dug to 50 ft to water level, 1937.
6	D	......	......	Dug to 70 ft to water in 1906, 326 gpm, drawdown 21 ft, 1906. Swimming pool and emergency use.
98	I	Top of rib inside pump shell.	+1.50	Yield, 1,625 gpm; drawdown, 18.5 ft when drilled.
......	D	......	......	Pit, depth 28 ft.
......	D	......	......	Pit, depth 35 ft.
......	II	Top of casing......	+.80	
......	D	......do......	+.50	Intended for domestic.

Table 12.—*Records of large-diameter wells near or on the valley*

No.	Well location no.	Sheet	Tract	Owner or name	Driller	Date completed	Topographic situation
						Mesilla Valley,	Dona Ana
83	23.2E.30.412b	11	74	NMAC, Horticultural well 3.	R. D. Sidey	May 1935	F
84	23.2E.30.412c	11	74	NMAC, Horticultural well 4.	Layne Texas	November 1947.	F
85	23.2E.31.213	11	129	NMAC, Agronomy well 1.	do	do	F
86	24.1E.1.111	12	33A1	Stahmann Farms, Inc., well 1.	J. F. Williams	August 1947.	F
87	24.1E.1.144	12	33A2	Stahmann Farms, Inc., well 3.	do	December 1947.	F
88	24.2E.5.234	13	18C	L. Beyers		January 1948.	F
89	24.2E.5.422	13	18A	E. L. Terry	Jack Daniels	October 1947.	F
90	24.2E.15.231	15	14	Dave Vickers	Morrison Bros	February 1948.	F
91	24.2E.22.444	15	63A	W. E. Evans		November (?) 1947.	F
92	24.3E.31.430	17		Paul Price		October 1946.	S
93	25.2E.2.221	17	72A1B	W. H. Walters	Joe Clary	November 1947.	F

No.	Well location no.	Pump			Yield		Drawdown below static level	
		Type	Size (in.)	Kind of power	Rate (gpm)	Date of measurement	Amount	Duration of test (hr)
						Mesilla Valley,	Dona Ana	
83	23.2E.30.412b	None	None	None	250 E	November 1946.		
84	23.2E.30.412c	T	8	E	695 R	November 1947.	21 R	
85	23.2E.31.213	T	8		1,100 R	do	40 R	
86	24.1E.1.111	T	8		1,200 R	1947	60 R	
87	24.1E.1.144	None	None	None				
88	24.2E.5.234	T	8	T				
89	24.2E.5.422	T	8	T	800 R			
90	24.2E.15.231							
91	24.2E.22.444	T	4					
92	24.3E.31.430	None	None	None	350 R	1946	19	
93	25.2E.2.221	T	6	T	600 R			

floor of the Rio Grande in Rincon and Mesilla Valleys—Continued

Altitude above sea level (ft)	Type of well	Depth of well (ft)	Diameter of well (in.)	Principal water-bearing bed: Depth to top of bed (ft)	Thickness (ft)	Character of material	Depth to which well is cased (ft)	Water level: Below land surface (ft)	Date of measurement
County, N. Mex.—Continued									
3,885 T	Dd	71	12	....	....	Sand and gravel.	71	16.97 17.63	Dec. 3, 1947 Feb. 12, 1948
3,885 T	Dr	95	14	26	60	........do........	92	16.89 17.53	Dec. 3, 1947 Feb. 10, 1948
3,880 T	Dr	70	14	....	....	........do........	....	13.16 14.13	Dec. 3, 1947 Feb. 10, 1948
3,875 T	Dr	331	15	44	104	........do........	306	9.65 14.02 14.93	July 31, 1947 Dec. 4, 1947 Feb. 12, 1948
3,875 T	Dr	100	16	....	....	........do........	....	12.48	Do.
3,870 T	Dr	60	12	....	....	....	....	....	....
3,870 T	Dr	80	12	....	....	Sand and gravel.	....	10.92 11.57	Dec. 5, 1947 Feb. 13, 1948
3,855 T	Dr	....	16	....	....	....	....	....	....
3,853 T	Dr	80	10	....	....	....	....	13.16 13.97	Dec. 5, 1947 Feb. 11, 1948
3,860 T	Dr	90	12	....	....	....	90	41.78 42.97	Dec. 4, 1947 Feb. 11, 1948
3,840 T	Dr	96	12	50	....	Sand and gravel.	....	11	December 1947

Specific capacity (gpm/ft)	Use of water	Measuring point: Description	Height above (+) or below (-) land-surface datum (ft)	Remarks
County, N. Mex.—Continued				
....	A	Top of collar on casing.	-1.50	Reported 1,100 gpm in 1935; well now sanded.
33	I	Top of casing	+.50	About 120 ft northwest of well 3.
28	I	............do............	+1.75	
20	I	............do............	+.87	
....	II	............do............	+.50	
....	I	....	....	
....	I	Top of casing	+.75	
....	II	....	....	Being drilled Feb. 13, 1948, depth, 48 ft.
....	II	Top of casing	+1.75	
18	II	............do............	+.50	
....	I	....	....	

Table 12.—*Records of large-diameter wells near or on the valley*

No.	Well location no.	Sheet	Tract	Owner or name	Driller	Date completed	Topographic situation
						Mesilla Valley,	Dona Ana
94	25.2E.4.422	18	6A	S. Y. Wilson......	Schumaker...........	November.. 1947.	F
95	25.2E.24.413	20	39	W. H. Randle....	...........do...........	October..... 1947.	F
96	25.3E.8.132	19	....	Mrs. Fuller........	....	January.(?).. 1948.	S
97	25.3E.19.331	21	83	W. E. Esslinger...	McBee................	November.. 1947.	F
98	26.3E.19.311	26	5	Leslie Hayes.......	Morrison Bros.........	February.... 1948.	S
99	26.3E.19.432	26	12	Judo Yabumoto...	Schumaker............	October..... 1947.	F
100	26.3E.30.114	26	16	O. E. Egbert......	Morrison Bros.........	February.... 1948.	S
101	26.3E.31.123	26	57	Jack Cox...........	............do...........	.......do......	S
102	27.3E.5.414	28	13A1	L. G. Little.......	Jack Daniels..........	March 1948	F
103	27.3E.6.213	28	5	Chester Little....	...........do..........	February.... 1948.	F
104	27.3E.15.143	30	7	Paul Price.........	Morrison Bros.........	January...... 1948.	F
						Mesilla Valley,	El
105	28.3E.12.311	32	12-7	O. C. Coles.......	Payne..................	January...... 1948.	F
106	28.3E.25.424	33	4-2	J. H. Lundgren...	....	1947.........	F
107	28.3E.25.442	33	4-21A	J. M. Taylor......	....	.......do......	F
108	28.3E.26.232	33	5-21	Erick Brandis......	....	.......do......	F

No.	Well location no.	Pump			Yield		Drawdown below static level	
		Type	Size (in.)	Kind of power	Rate (gpm)	Date of measurement	Amount	Duration of test (hr)
						Mesilla Valley,	Dona Ana	
94	25.2E.4.422	T	10	G	1,100 M	Dec. 4, 1947....	42 M	4
95	25.2E.24.413	T	6	T	600 R	1947..............	35 R	....
96	25.3E.8.132	T	8	G	....	....	....	....
97	25.3E.19.331	T	8	T	1,100 R	1948..............	33 R	....
98	26.3E.19.311	T	8	G	600 R	..........do........	11 R	....
99	26.3E.19.432	T	8	T	900 R	1947..............	60 (?)R	....
100	26.3E.30.114	None	None	None	800 R	1948..............	47 R	....
101	26.3E.31.123	None	None	None	....	....	....	....
102	27.3E.5.414	T	10	G	1,500 M	Mar. 25, 1948	35	48
103	27.3E.6.213	T	8	G	1,100 E	..........do........	34	4
104	27.3E.15.143	None	None	None	800 R	1948..............	40 R	....
						Mesilla Valley,	El	
105	28.3E.12.311	T	8	T	....	....	....	....
106	28.3E.25.424	T	4	G	....	....	....	....
107	28.3E.25.442	C	1½	E	....	....	....	....
108	28.3E.26.232	None	None	None	....	....	....	....

floor of the Rio Grande in Rincon and Mesilla Valleys—Continued

Altitude above sea level (ft)	Type of well	Depth of well (ft)	Diameter of well (in.)	Principal water-bearing bed: Depth to top of bed (ft)	Principal water-bearing bed: Thickness (ft)	Principal water-bearing bed: Character of material	Depth to which well is cased (ft)	Water level: Below land surface (ft)	Water level: Date of measurement
County, N. Mex. —Continued									
3,840 T	Dr	95	20	50	....	Sand and........ gravel.	....	15.58	Dec. 4, 1947
3,823 T	Dr	130	12	....	....	....	....	8.57	Do.
								9.20	Feb. 11, 1948
3,845 T	Dr	....	18	....	....	....	....	18.04	Do.
3,824 T	Dr	90	16	58	....	Sand and........ gravel.	....	9.36	Dec. 4, 1947
								9.90	Feb. 11, 1948
3,810 T	Dr	132	14	....	....	....	....	23.63	Do.
3,800 T	Dr	131	16	59	27	Gravel..........	90	10.17	Dec. 4, 1947
3,800 T	Dr	107	14	53	....	Sand and........ gravel.	107	8.30	Feb. 11, 1948
3,800 T	Dr	90	16	52	20	........do.........	....	10	February 1948
....	Dr	82	14	40	42	Gravel..........	82	13	March 1948
3,785 T	Dr	126	14	55	30	.......do..........	85	17	Do.
3,780 T	Dr	91	16	42	38	Sand and........ gravel.	....	8.42	Feb. 11, 1948
Paso County, Tex.									
3,755 T	Dr	....	....	....	....	....	....	7.04	Feb. 11, 1948
....	Dr	....	....	....	....	....	....	....	....
....	Dr	60	8	....	....	....	....	....	....
....	Dr	64	8	....	....	Fine sand.......	....	....	....

Specific capacity (gpm/ft)	Use of water	Measuring point: Description	Measuring point: Height above (+) or below (-) land-surface datum (ft)	Remarks
County, N. Mex. —Continued				
26	I	Base of pump...........	+1.00	Reported well improved to 1,500 gpm; drawdown, 22 ft, February 1948.
17	I	Top of casing...........	.00	
....	I	.............do............	+.50	
33	I	.............do............	.00	
55	I	.............do............	+2.00	Temperature 70.5 F. See analysis.
15	I	.............do............	+.50	Well sanded in (?), measured 250 gpm; drawdown, 22 ft, February 1948.
17	II	..............do............	+3.00	
....	II	....	....	Being completed Feb. 13, 1948.
43	I	....	....	
32	I	....	....	
20	II	Top of casing...........	+2.00	
Paso County, Tex.				
....	I	Top of casing...........	+1.50	A river pump located west of this well.
....	I	....	....	Upper Valley Nursery.
....	ID	....	....	
....	II	....	....	

Table 13.—*Records of wells principally above the valley*

Altitude: A, determined by aneroid barometer; T, determined from U. S. Geological Survey topographic quadrangle maps.
Type of well: Dd dug and drilled; Dr, drilled; Du, dug; J, jetted.
Depth of well: M, measured; otherwise reported.
Water level: Reported figures given to nearest foot.

No.	Well: Location no.	Well: Field name	Owner or name	Driller	Date completed
					Sierra County,
1	19.5.1,	Mexican Querva	Homer Jones		1925
2	19.5.16.100	Twin Mills West	do.		1900
3	19.5.28.300	Iron Mill	do.	Andy Romenger	1917 (?)
					Dona Ana
4	18.1E.27.430	Red Lake	Jornada Experimental Range.		
5	18.4.5.211		C. W. Kight		1946 (?)
6	18.4.8.410	Brewster	Brewster	Elliott	1916
7	18.4.9.130	Hedgecock	R. F. Hedgecock	Schoptaugh	1945
8	18.4.34.211	Simms	Simms	Boggs	1940 (?)
9	18.4.35.221	Boggs	Boggs	do.	1940
10	19.1E.1.221	Middle well	Jornada Experimental Range.	Turney	
11	19.2E.33.120	Headquarters West	do.		
12	19.2E.33.120a		do.		
13	19.2E.33.210	Headquarters East	do.		1937
14	19.4E.31.420	Little well	do.		
15	19.4.29.130	East well	Homer Jones	Andy Romenger	1917
16	19.4.30.240	Hackett Place	do.	Boyd Lusk	1936
17	20.1E.4.120	West well	Jornada Experimental Range.		1906
18	20.1E.8.330	A. & M. Camp	New Mexico Coll. of Agr. and Mech. Arts.	Dutch Chandler Jim Sewell	1930

No.	Location no.	Depth to which well is cased (ft)	Water level: Below land surface (ft)	Water level: Date of measurement	Type of pump	Kind of power
						Sierra County,
1	19.5.1.		28.05	June 25, 1947	Pl	W
2	19.5.16.100		99.80	do.	Pl	W
3	19.5.28.300		118.20	do.	Pl	W
						Dona Ana
4	18.1E.27.430		195	April 1947	Pl	W
5	18.4.5.211		3 to 4	1946	C	E
6	18.4.8.410				None	
7	18.4.9.130	100	4.72	July 15, 1947	None	
8	18.4.34.211				None	
9	18.4.35.221	112	8	1940	Pl	E
10	19.1E.1.221	350	236.05	Apr. 17, 1947	Pl	W
11	19.2E.33.120				Pl	W
12	19.2E.33.120a				Pl	G
13	19.2E.33.210	355	239.50	Mar. 26, 1948	Pl	W
14	19.4E.31.420		100		Pl	W
15	19.4.29.130	30	160	1947	Pl	W
16	19.4.30.240				Pl	W
17	20.1E.4.120	300	290 to 300	1947	Pl	W
18	20.1E.8.330	356	290	do.	Pl	W

floor of the Rio Grande in Sierra and Dona Ana Counties, N. Mex.

Type of pump: AL, air lift; C, centrifugal; Pl, plunger; T, turbine.
Kind of power: B, butane engine; E, electric motor; G, gasoline motor; T, tractor engine; W, wind.
Use of water: A, abandoned; D, domestic; I, irrigation; RR, railroad; S, stock.

Topographic situation	Altitude above sea level (ft)	Type of well	Depth of well (ft)	Diameter of well (in.)	Principal water-bearing bed: Depth to top of bed (ft)	Principal water-bearing bed: Thickness (ft)	Principal water-bearing bed: Character of material
N. Mex.							
In arroyo bed	4,225 A	Du	40	60	......	......	Sand and gravel.
do	4,490 A	Du	118 M	50	......	......	Cemented conglomerate.
On mesa	4,500 A	Dr	138 M	6	......	......	Gravels.
County, N. Mex.							
do	4,355 A	Dr	350	6	......	......	Quicksand.
Valley floor	4,066 T	J	82	2½	......	......	......
do	4,058 T	Dr	200(?)	6	......	......	......
do	4,059 T	J	100	2½	......	......	Sand and gravel.
do	4,036 T	J	245	2½	......	......	......
do	4,036 T	J	214	3	......	......	......
On mesa	4,350 A	Dr	350	6	......	......	Quicksand.
do	4,355 A	Dr	......	......	......	......	......
do	4,350 A	Dr	......	6	......	......	......
do	4,340 A	Dr	360	6	310	50	Quicksand and sandstone.
In canyon	5,235 A	Dr	103	6	......	......	......
On mesa	4,440 A	Dr	180	6	......	......	......
......	......	Dr	160	12	......	......	......
......	4,360 A	Dr	390	6	......	......	......
......	4,395 A	Dr	373	6	295	78	Quicksand.

Use of water	Quality	Measuring point: Description	Measuring point: Height above (+) or below (-) land-surface datum (ft)	Remarks
N. Mex.—Continued				
S	Good	Top of tin well cover	+0.30	
S	do	Top of wooden well cover.	+.50	Reportedly weak.
S	do	Top of casing	+1.00	
County, N. Mex.				
S	Fair	......	......	
D	do	......	......	Reportedly good quality for area.
A	Bad	......	......	
A	Poor	Top of casing	+5.80	Too hard for domestic use.
A	do	......	......	Clay from 70 to 110± ft and 112± to 245 ft. Rock 110± to 112± ft.
D	Good	......	......	
S	Fair	Top of casing	+1.43	
D, S	......	......	......	
D	......	......	......	
D, S	Good	Top of steel pipe clamps	+.50	
D, S	......	......	......	Abandoned Civilian Conservation Corps camp.
S	Good	......	......	Reported 18 gpm.
S	do	......	......	Well not visited. Reported 6 gpm.
S	Poor	......	......	Temperature 75F.
S	......	......	......	

Table 13.—*Records of wells principally above the valley floor of*

No.	Well: Location no.	Well: Field name	Owner or name	Driller	Date completed
					Dona Ana County,
19	20.1E.14.140	Co-op	Jornada Experimental Range.	Jim Sewell	February. 1936.
20	20.1E.35.220	Headquarters	New Mexico Coll. of Agr. and Mech. Arts.	do	1905 (?)
21	20.2E.28.330	South well	Jornada Experimental Range.		
22	20.3E.18.210	Taylor well	do		
23	20.3E.36.330	T. Gardner spring.	W. F. Isaacs		
24	20.1.10.	Oakes	New Mexico Coll. of Agr. and Mech. Arts.		January. 1936.
25	20.1.11.310	Mayfield	do		
26	20.1.26.210	Selden	do		1900 (?)
27	20.1.30.330	Buckle Bar	do		1935
28	20.1.31.320		Beal	Schoptaugh	1942
29	20.1.31.320a		do	do	1945
30	20.2.13.330		C. H. Ward		1938
31	20.2.24.110		C. C. Rice	Smith	March. 1947.
32	20.2.25.230		Ernest Ward	Schoptaugh	1937
33	20.2.25.230a		do		1931
34	20.2.34.		Beal	Schoptaugh	1943
35	20.4.6.210	Hackett	Homer Jones	Lusk	1935
36	20.5.8.220	Headquarters	do		
37	21.1E.15.230	Wagner	New Mexico Coll. of Agr. and Mech. Arts.		
38	21.1E.22.240	Cleofos	do		1900 (?)

No.	Location no.	Depth to which well is cased (ft)	Water level: Below land surface (ft)	Water level: Date of measurement	Type of pump	Kind of power
						Dona Ana County,
19	20.1E.14.140	356	325 319.74	February 1936 Mar. 26, 1948	Pl	W
20	20.1E.35.220	356	290	1947	Pl	W, G
21	20.2E.28.330	365 (?)	230	do	Pl	W
22	20.3E.18.210	400	360.00	Mar. 18, 1947	None	
23	20.3E.36.330		Flowing	Mar. 4, 1947		
24	20.1.10.	316				
25	20.1.11.310	366	355	1947	Pl	W
26	20.1.26.210	267 (?)	267	do	Pl	W
27	20.1.30.330	18	13	do	Pl	W
28	20.1.31.320	45	20	do	Pl	W
29	20.1.31.320a		14	do	Pl	W
30	20.2.13.330	26	24	do	Pl	W
31	20.2.24.110		17	do	Pl	Hand
32	20.2.25.230	70	38	do	Pl	W
33	20.2.25.230a	21	16	do	Pl	W
34	20.2.34.		20 to 25		Pl	W
35	20.4.6.210	7	120	1947	Pl	W
36	20.5.8.220	0	53.95	June 24, 1947	Pl	W, G
37	21.1E.15.230	0	4	1947	Pl	W
38	21.1E.22.240	0	6		Pl	W

the Rio Grande in Sierra and Dona Ana Counties, N. Mex. — Continued

Topographic situation	Altitude above sea level (ft)	Type of well	Depth of well (ft)	Diameter of well (in.)	Principal water-bearing bed: Depth to top of bed (ft)	Principal water-bearing bed: Thickness (ft)	Principal water-bearing bed: Character of material
N. Mex.—Continued							
...	4,415 A	Dr	356	6.	348	8	Sandstone.
...	4,390 A	Dr	373	6	295	78	Quicksand.
...	4,325 A	Dr	365	6	...	...	Do.
...	4,455 A	Dr	499	6	...	...	...
...	...	...	...	...	...	...	...
...	...	Dr	320	6	312	8	Quicksand.
...	4,380 A	Dr	369	6	355	...	Do.
...	4,335 A	Dr	284	6	267	17+	Do.
...	...	Dd	18	4	...	...	Gravel.
...	4,010 A	Dr	93	6	45	...	Sand and gravel.
...	4,006 A	J	59	6	59	...	Do.
...	...	Du	26	6	0	26	Do.
...	...	J	119	3	97+	...	Sand.
Floor of arroyo...	4,023 A	Dr	70	6	68	2	Gravel.
Valley floor...	4,010 A	Du	21	8	...	...	Sand and gravel.
In Broad Canyon...	...	Dr	124	6	...	...	Do.
...	4,475 A	Dr	160	6	...	...	Gravels.
...	4,440 A	Du	60	...	0	60	Do.
Floor of arroyo...	4,525 T	Du	16	60 (?)	0	16	Do.
...do...	4,520 T	Du	20	60 (?)	0	15	Do.

Use of water	Quality	Measuring point: Description	Measuring point: Height above (+) or below (-) land-surface datum (ft)	Remarks
N. Mex.—Continued				
S	Good	Top of casing...	+0.90	
D, S	...do...	...	...	Reported 9 gpm.
S	Poor	...	...	
A	...	Top of casing...	+1.00	
S	Fair	...	...	Spring; flow estimated 5 gpm; has sulphur taste. Temperature 58 F.
...	...	...	...	Well not located.
S	...	...	...	
S	...	...	...	See analysis.
S	...	...	...	
D, S	Hard	...	...	Water salty at 93 ft.
D, S	...	...	...	Water hit at 59 ft below clay.
D, S	Salty	...	...	
D, S	Good	...	...	Salt water at 97 ft.
S	Salty	...	...	Reported good yield.
D, S	Hard	...	...	
S	Good	...	...	
S	...do...	...	...	
D, S	...do...	Top of pipe clamps...	+1.45	Temperature 67 F. Luna County.
S	...	...	...	Dry in summer, weak.
S	...	...	...	Reported 14-ft drawdown. Winter springs cased in for supply.

Table 13.—*Records of wells principally above the valley floor of*

No.	Well: Location no.	Well: Field name	Owner or name	Driller	Date completed
					Dona Ana County,
39	21.2E.12.222	Parker	Edwin Parker	J. F. Williams	April 1947.
40	21.2E.15.244	Stuart	Jornada Range Reserve		
41	21.2E.25.430	East Headquarters	W. F. Isaacs		June 1907.
42	21.2E.25.430a	West Headquarters	do		1899
43	21.3E.25.430	Home	Ollie Isaacs		1900
44	21.4E.30.230	Merrimac mine spring.	do (?)	American Smelting & Refining Co.	
45	21.1.9.230		O. F. Smith		
46	21.2.31.440	Adobe	H. S. Bissell		
47	22.1E.28.140		T. L. Simpson	Jeff Chandler	
48	22.1E.28.310		do		
49	22.1E.28.320		do		
50	22.2E.13.411		J. W. Daugherty	Boone	March 1948.
51	22.2E.31.340		W. F. Isaacs	Dutch Chandler	1920
52	22.3E.2.240		Henry Olson		
53	22.3E.2.410		S. A. Walter	Dickinson brothers	1931
54	22.3E.2.420		Bert Holmes		1946
55	22.3E.11.320		E. J. Isaacs	Ed Boone	1939
56	22.3E.23.320	West well	do		1922
57	22.3E.23.320a	East well	do	Ed Boone	1939
58	22.3E.26.420	Mine house spring.	do		

No.	Location no.	Depth to which well is cased (ft)	Water level: Below land surface (ft)	Water level: Date of measurement	Type of pump	Kind of power
						Dona Ana County,
39	21.2E.12.222	420 (?)	294	July 1947	Pl	G
40	21.2E.15.244					
41	21.2E.25.430		300	1947	Pl	W
42	21.2E.25.430a		290.50	Feb. 26, 1947	Pl	W
43	21.3E.25.430	75	75	1947	Pl	W
44	21.4E.30.230		Flowing	Mar. 5, 1947		
45	21.1.9.230		30.07	May 26, 1947	Pl	W
46	21.2.31.440		90		Pl	W
47	22.1E.28.140	242	5		C	E
48	22.1E.28.310	42	5		C	E
49	22.1E.28.320	162	5		C	E
50	22.2E.13.411	430	375.04	Mar. 26, 1948	None	
51	22.2E.31.340		164.00	Mar. 18, 1947	Pl	W
52	22.3E.2.240	10± (?)	187	1947.	Pl	W
53	22.3E.2.410	150	140	do	Pl	W
54	22.3E.2.420	50	115.30	Mar. 5, 1947	Pl	W
55	22.3E.11.320	40	135	1947	Pl	W
56	22.3E.23.320	122	135	do	Pl	W
57	22.3E.23.320a	40	135	do	Pl	W
58	22.3E.26.420		Flowing	Mar. 12, 1947		

the Rio Grande in Sierra and Dona Ana Counties, N. Mex.— Continued

Topographic situation	Altitude above sea level (ft)	Type of well	Depth of well (ft)	Diameter of well (in.)	Principal wate -bearing bed: Depth to top of bed (ft)	Principal wate -bearing bed: Thickness (ft)	Principal wate -bearing bed: Character of material
N. Mex.—Continued							
....	4,370 T	Dr	631	6	335	165	Sandstone (?).
....	4,290 T	Dr	250	4 ½	....	....	....
On mesa................	4,360 T	Dr	342	6	320	5	Gravel.
..............do..........	4,360 T	Dr	325	4	320	5	Do.
....	5,190 T	Dr	75	6	....	....	....
Slope of San Andres..	5,500 T	Dr	125 (?)	....	....	....	....
In canyon..............	....	Dr	....	6	....	....	....
In Rolling Hills	4,710 T	Dr	180	6	....	....	....
Valley floor	....	J	242	2 ½	....	....	Sand and gravel.
............do...........	....	Dr	42	4	5	37	Do.
............do...........	....	J	162	2 ½	150	....	Do.
On mesa...............	4,450	Dr	430	6	386	....	Do.
Between arroyos........	4,060 A	Dr	175	6	165	10	Gravel.
In San Augustine Pass., Organ Mountains.	5,110 T	Dr	198	6	187	....	Limestone and shale (?).
............do............	5,030 T	Dd	155	6	....	....	Limestone (?).
............do............	5,090 T	Dr	200	6	....	....	Limestone and shale (?).
At foot of Organ....... Mountains.	4,890 T	Dr	204	6	....	....	Do.
............do............	4,935 T	Dd	212	6	....	....	Do.
............do............	4,935 T	Dr	204	6	....	....	Do.
In canyon..............	5,360 T	....	....	....	....	....	....

Use of water	Quality	Measuring point: Description	Measuring point: Height above (+) or below (-) land-surface datum (ft)	Remarks
N. Mex.—Continued				
II	....	....	....	Reported 40 gpm.
A	....	....	....	Plugged.
D, S	Good	....	....	Reported 30 gpm.
D, S	.....do....	Top of 4 by 4 pipe...... clamps.	+1.5	Reported by Lee, W. T., Water-Supply Paper 188. Pumps dry.
D, S	Hard	....	....	Well bottoms in old mine tunnel.
S	.....do....	....	....	Core test. Other core tests in immediate vicinity. Small flow.
D, S	....	Top of casing...........	+1.20	
D, S	Good	....	....	
D, S	.....do....	....	....	Reported 15 gpm. See analyses.
D, S	Poor	....	....	Reported 15 gpm. See analysis.
D, S	Good	....	....	See analysis.
....	.....do....	Top of collar on casing	+1.50	Temperature 76.5 F. See analysis.
S	Fair	Top of pipe column.....	+4.30	
D	Mineral taste.	....	....	
D, S	Hard	....	....	
D, S	.....do....	Top of casing...........	+1.30	
S	.....do....	....	....	
D, S	.....do....	....	....	Dug 112 ft, reported 12 gpm.
D, S	.... do....	....	....	
S	.....do....	....	....	Spring, flow 2 to 3 gpm estimated; does not go dry.

Table 13.—*Records of wells principally above the valley floor of*

No.	Well: Location no.	Well: Field name	Owner or name	Driller	Date completed
					Dona Ana County,
59	22.1.19.330	Hawkins..........	H. S. Bissell..........	....	....
60	22.2.21.330	Big Gap..........	..........do..........	....	....
61	22.3.16.340	Little Mills North	..........do..........	....	....
62	22.3.16.340a	Little Mills South	..........do..........	....	....
63	22.4.10.230	Monterey well....	Weldon Burris..........	E. H. Boone........	....
64	22.4.19.340	....	..........do..........	Herman MacElhaney.	1929......
65	23.1E.30.210	....	Norwood..........	....	....
66	23.2E.6.332a	....	Fay Sperry..........	Dickinson brothers.	....
67	23.2E.7.320	....	Will Washington..........	....	1947......
68	23.2E.29.332	....	Las Cruces Ice Co.........	Lee Burdick........	....
69	23.2E.30.441	....	Ray Langford..........	Jeff Chandler.......	1945......
70	23.2E.30.443	....	Milos Rath..........	..........do........	....
71	23.3E.1.340	Hayner resort......	F. M. Hayner..........	....	....
72	23.3E.12.230	....	R. E. Boyd..........	....	1938......
73	23.3E.13.330	....	E. J. Isaacs..........	....	....
74	23.3E.21.310	....	..........do..........	....	1907......
75	23.1.15.211	....	Picacho Oil & Gas Syn...	....	1941......

No.	Location no.	Depth to which well is cased (ft)	Water level: Below land surface (ft)	Water level: Date of measurement	Type of pump	Kind of power
						Dona Ana County,
59	22.1.19.330	....	151.00	Feb. 4, 1947......	Pl	W
60	22.2.21.330	277	235.60	..........do..........	Pl	W
61	22.3.16.340	75	12.00	Feb. 5, 1947......	Pl	W
62	22.3.16.340a	75	....	....	....	....
63	22.4.10.230	383	310	1942 (?)..........	Pl	W
64	22.4.19.340	224	211	..........do..........	Pl	W,G
65	23.1E.30.210	....	297.65	Feb. 6, 1947......	Pl	W,E
66	23.2E.6.332a	....	65	....	Pl	W
67	23.2E.7.320	67	57.60	Apr. 10, 1947.....	Pl	W
68	23.2E.29.332	224	16	....	C	E
69	23.2E.30.441	268	11	....	C	E
70	23.2E.30.443	157	17	....	C	E
71	23.3E.1.340	....	0.30	Mar. 13, 1947.....	Pl	G
72	23.3E.12.230	....	69	1947..........	Pl	W
73	23.3E.13.330	....	65	..........do..........	Pl	W
74	23.3E.21.310	100 (?)	200	....	Pl	W
75	23.1.15.211	....	550	....	None	....

the Rio Grande in Sierra and Dona Ana Counties, N. Mex.— Continued

Topographic situation	Altitude above sea level (ft)	Type of well	Depth of well (ft)	Diameter of well (in.)	Principal water-bearing bed: Depth to top of bed (ft)	Principal water-bearing bed: Thickness (ft)	Principal water-bearing bed: Character of material
N. Mex. —Continued							
Flat plain	4,460 T	Dr	180	8			
Gap in range of hills	4,610 T	Dr	280	6			Sand and gravel.
	4,610 T	Dr		6			Alluvial fill.
W. side of draw	4,610 T	Dr	75	6			Do.
Magdalena Draw	4,815 T	Dr	383	4½			Do.
In draw		Dr	224	5½	220		
Bluff above valley floor.	4,180 T	Dr	330	6			
do	3,950 T	Dr	130		130	5	Sand.
Slope off Rio Grande valley.	3,940 T	Dd	67	5			Gravel and sand.
Valley floor		Dr	224	4½			
do		J	268	3			Sand and gravel.
		J	157	2½	148	9	
In Ice Canyon	5,650 T	Du	9				Arroyo gravel.
do	5,780 T	Du					
	5,600 T	Dr	70-75				Arroyo gravel.
	4,590 T	Dr	220	6			
On mesa	4,480 T	Dr	3,196	8			

Use of water	Quality	Measuring point: Description	Measuring point: Height above (+) or below (-) land-surface datum (ft)	Remarks
N. Mex. —Continued				
S		Top of casing	+0.50	Reported 6 to 8 gpm.
S		do	+1.80	Reported 6 gpm.
S		do	+.70	
S				
S	Good			Reported 4 to 5 gpm.
D, S	Fair			Water warm, slight mineral taste.
D		Top of casing	+.70	
D	Good			Reported total dissolved solids, upper water 2,130 ppm, lower water 720 ppm.
D	do	Top of casing	+1.95	
Ice	do			Reported 10 gpm, 12-ft drawdown. See analysis.
D	do			Reported 6 gpm. Reported total dissolved solids 300 ppm; hardness 150.
D	do			
D, S		Top of well curb	+3.2	Reported 12 gpm. Well about 100 ft behind dam across arroyo.
S				
S	Good			Reported 10 gpm; pumps dry in 2 hours.
S	do			Reported 3 gpm.
A	Poor			Oil test. Total dissolved solids, reported 5,430 ppm.

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Table 13.—*Records of wells principally above the valley floor of*

No.	Well: Location no.	Well: Field name	Owner or name	Driller	Date completed
					Dona Ana County,
76	23.1.32.330	Dickinson	H. S. Bissell	Dickinson brothers	1935
77	23.2.13.310	Headquarters East	do.	Payne	
78	23.2.13.310a	Headquarters West	do.	do (?)	
79	23.2.23.330	Horse Trap	do.		
80	23.2.27.330	Little Gap East	do.		
81	23.2.27.330a	Little Gap West	do.		
82	23.3.4.140	Kerr	do.	Payne	1947
83	23.3.9.330	Le Febre	do.		
84	23.3.20.420	Temple East	do.		
85	23.3.20.420a	Temple West	do.		
86	23.4.18.111		L. F. Burris		
87	23.4.18.310		do.		
88	23.4.26.440	Mimms	do.		1916
89	23.4.32.144		State of New Mexico	Al Kimball	1936
90	24.3E.31.230	Mossman ranch	Paul Price		1900 (?)
91	24.1.22.120		Norwood		
92	24.3.4.420	Brass	H. S. Bissell	Payne	
93	24.3.5.330	Highway	do.		
94	24.3.6.320		Andy Coldiron	Bob Payne	1941
95	24.3.6.430		F. C. Leach		1926

No.	Location no.	Depth to which well is cased (ft)	Water level: Below land surface (ft)	Water level: Date of measurement	Type of pump	Kind of power
						Dona Ana County
76	23.1.32.330	165	350		Pl	W
77	23.2.13.310		130 (?)		Pl	W
78	23.2.13.310a	180	117.70	Feb. 4, 1947	Pl	W,G
79	23.2.23.330				Pl	W
80	23.2.27.330	180	148.00	Feb. 4, 1947	Pl	W
81	23.2.27.330a	172	149.20	do.	Pl	W
82	23.3.4.140	1,005 (?)	4.20	Feb. 5, 1947	Pl	W,G
83	23.3.9.330	80	30.50	do.	None	
84	23.3.20.420		54.20	do.	Pl	W
85	23.3.20.420a		85.60	do.	Pl	W
86	23.4.18.111	0	14	1942	Pl	W,G
87	23.4.18.310	0	18	do.	None	
88	23.4.26.440		78.40	Feb. 7, 1947	Pl	W,G
89	23.4.32.144				None	
90	24.3E.31.230	130	90		Pl	W
91	24.1.22.120		300.00+	Feb. 10, 1947	Pl	W,G
92	24.3.4.420		333 300.00+	 Feb. 5, 1947	Pl	W
93	24.3.5.330		78.15	do.	Pl	W
94	24.3.6.320	117	98	1942 (?)	Pl	W
95	24.3.6.430	135	99.35	Feb. 17, 1947	Pl	W

the Rio Grande in Sierra and Dona Ana Counties, N. Mex.—Continued

Topographic situation	Altitude above sea level (ft)	Type of well	Depth of well (ft)	Diameter of well (in.)	Principal water-bearing level: Depth to top of bed (ft)	Thickness (ft)	Character of material
N. Mex.—Continued							
	4,410 T	Dr	501	8	430	71	Sand.
On mesa	4,420 T	Dr	200	6			
do.	4,420 T	Dr	180	6			
	4,460 T	Dr	177	8			
	4,470 T	Dr	180	6			
Between hills	4,470 T	Dr	172	6			
	4,480 T	Dr	1,005	6			
West side of Mason Draw.	4,450 T	Dr	80	6			
do.	4,390 T	Dr		6			
do.	4,400 T	Dr	366	6			
Goodsight Draw		Du	18				Caliche and gravel.
do.		Du	20				
	4,360 T	Dr	200(?)	6			
		Dr	280				
On slope of valley	3,930 T	Dr	130	5¼	108	22	Quicksand.
	4,220 T			6			
	4,360 T	Dr	366	6			
West side of Mason Draw.	4,330 T	Dr		6			
	4,330 T	Dr	138	6	60	40	Dark sand.
	4,325 T	Dr	135	6			

Use of water	Quality	Measuring point: Description	Height above (+) or below (-) land-surface datum (ft)	Remarks
N. Mex.—Continued				
S	Good			Reported 4 gpm.
D, S				
D, S		Top of casing	+0.70	Reported 12 to 14 gpm.
S				
S		Top of casing	+1.25	Reported 10 to 12 gpm.
S		Top of pipe clamps	+.85	Do.
S		Top of casing	+1.85	Reported 4 to 5 gpm.
A	Good	do.	+1.45	Very weak well.
S		do.	+1.50	
S		do.	+.65	Weak well.
D, S	Good			Three windmill wells at this location.
				South of Burris headquarters.
S	Good	Top of casing	+.80	Reported 7 gpm.
				No water.
S	Poor			Estimated 25 gpm.
D, S				
D, S				Reported 4 gpm.
S		Top of casing	+2.60	Temperature 69 F. See analysis.
D, S	Good			
D	do.	Top of casing	+1.10	

Table 13.—*Records of wells principally above the valley floor of*

No.	Well: Location no.	Well: Field name	Owner or name	Driller	Date completed
					Dona Ana County,
96	24.3.7.410	Works well......	John Biggs....................	Zeke Mordyke.....	1929 (?)..
97	24.3.8.310	West Line.......	H. S. Bissell...............	Bob Payne..........	1936......
98	24.3.25.230	Aden wells.......	..............do...............	....	....
99	24.4.2.111	....	L. F. Burris................	B. Armstrong.......	1941-42..
100	24.4.12.220	Phillips...........	Phillips.......................	E. H. Boone........	1934-35..
101	24.4.12.230	Biggs ranch......	John Biggs....................	Strickland...........	1936 (?)..
102	24.4.12.322	....	..............do..............	E. H. Boone........	1928 (?)..
103	25.1E.6.330	....	L. E. Bowman...............	....	1942 (?)..
104	25.1E.19.240	....	..............do..............	....	....
105	25.2E.28.220	....	Fred Nunn (?)..............	Bob Payne..........	....
106	25.2E.31.130	....	..............do..............	....	1916......
107	25.3E.22.120	Hutchins..........	Paul Price....................	....	1900......
108	25.2.12.240	Perry.............	Ben F. Perry................	Shell Norwood......	1890 (?)..
109	25.2.30.320	R. T. ranch.....	Johnson Bros................	....	1946......
110	25.3.2.220	Aden station.....	H. S. Bissell...............	....	....
111	25.3.10.240	....	Johnson Bros.................	Bob Payne..........	1947......
112	25.4.10.120	O. D. ranch..... North well.	..............do..............	Andy Romenger....	1900 (?)..
113	25.4.22.110	O. D. ranch,.... South well.	..............do..............	....	....
114	26.1E.18.220	Nunn ranch.......	Fred Nunn....................	....	1915......
115	26.2E.17.240	....	R. A. Gardner.............	U. S. Grazing...... Service.	1942......
116	26.2E.31.410	....	..............do..............	....	1917......
117	26.3E.9.221	....	Berino Cotton Gin.........	....	July 1947
118	26.3E.11.111	....	Paul Price....................	....	1943......

No.	Location no.	Depth to which well is cased (ft)	Water level: Below land surface (ft)	Water level: Date of measurement	Type of pump	Kind of power
						Dona Ana County,
96	24.3.7.410	....	100+	1942 (?).............	Pl	W
97	24.3.8.310	....	169.19	Mar. 25, 1948.....	Pl	W
98	24.3.25.230	....	178.80	Feb. 11, 1947.....	None	....
99	24.4.2.111	0	136.56	Sept. 16, 1942.....	....	....
100	24.4.12.220	170	96.31	Feb. 7, 1947.......	Pl	W, G
101	24.4.12.230	....	91.28	..........do.........	Pl	W
102	24.4.12.322	130	120	1942 (?)............	Pl	W, G
103	25.1E.6.330	....	300.00+	Feb. 11, 1947.....	Pl	W
104	25.1E.19.240	....	375	....	Pl	W, G
105	25.2E.28.220	100	104.65	Apr. 29, 1947......	Pl	W
106	25.2E.31.130	360	350 to 360	....	None	....
107	25.3E.22.120	185	155	....	Pl	W, G
108	25.2.12.240	398	383	1947................	Pl	W, G
109	25.2.30.320	217	217	....	Pl	W
110	25.3.2.220	....	444 (?) 300.00+	.... Feb. 11, 1947.....	Pl	W
111	25.3.10.240	30	120	1947................	Pl	W
112	25.4.10.120	....	185.95	Feb. 7, 1947.......	Pl	W
113	25.4.22.110	....	121.20	..........do.........	Pl	W
114	26.1E.18.220	437	390	....	Pl	W, G
115	26.2E.17.240	....	321	....	Pl	W
116	26.2E.31.410	338	317	....	Pl	W
117	26.3E.9.221	148	4	1947................	G	E
118	26.3E.11.111	50	15	....	Pl	W

the Rio Grande in Sierra and Dona Ana Counties, N. Mex.—Continued

Topographic situation	Altitude above sea level (ft)	Type of well	Depth of well (ft)	Diameter of well (in.)	Principal water-bearing bed: Depth to top of bed (ft)	Principal water-bearing bed: Thickness (ft)	Principal water-bearing bed: Character of material
N. Mex.—Continued							
Mason Draw...	4,315 T	Dr	140	...	...	...	Gravel.
...	4,325 T	Dr	262	6	...	...	...
...	4,550 T	Dr	...	7	...	...	...
...	4,320 T	Dr	480	...	265	...	...
...	4,320 T	Dr	170	4	140	30	Sand and gravel.
On mesa...	4,310 T	Dr	200(?)	6	140	60	... Do.
...	...	Dr	130	6	...	...	...
On mesa...	4,210 T	Dr	400±	6	...	...	...
...	4,160 T	Dr	400±	6	...	...	...
...	3,920 T	Dr	120	7	...	...	...
...	4,170 T	Dr	360	6	...	...	...
...	3,980 T	Dr	185	8	170	15	Clay and fine sand.
...	4,225 T	Dr	398	6	...	...	...
...	4,280 T	Dr	217	6	200	17	Sand.
...	4,480 T	Dr	444	8	506	21	...
...	4,420 T	Dr	527	8	...	...	Gravel.
...	4,220 T	Dr	200	6	...	...	Sand and gravel.
...	4,170 T	Dr	300+	6	...	...	... Do.
...	4,210 T	Dr	440	6	400	40	Quicksand.
...	4,125 T	Dr	340	6	320	20	Sand.
...	4,125 T	Dr	338	8	317	21	Do.
Valley floor...	...	J	148	2½	148	...	Do.
...	3 860 T	Dr	50	4	...	...	Sand and gravel.

Use of water	Quality	Measuring point: Description	Measuring point: Height above (+) or below (-) land-surface datum (ft)	Remarks
N. Mex.—Continued				
D, S	Good	...	...	Weak well.
S	...	Top of casing...	+1.50	Reported 3 gpm.
A	...	...do...	+.75	North well of 3 wells.
...	...	Ground surface...	...	
D	Good	Top of casing...	+.45	
D, S	...	...do...	+1.00	Southwesternmost of 2 wells.
S	...	...	...	Hit malpais; strong well.
S	...	...	...	Reported 10 to 12 gpm.
D, S	...	...	...	
D, S	Good	Top of casing...	+.75	Reported 5 to 7 gpm.
A	...	...	...	Plugged.
S	Good	...	...	Reported 40 gpm.
S	...do...	...	...	Reported 8 gpm.
D, S	...do...	...	...	
S	...	...	...	Reported 5 gpm.
S	Bad	...	...	
S	Good	Top of concrete...	+1.10	North well of 2 wells.
S	...	Top of pipe clamps...	+2.00	
D, S	Good	Top of casing...	+.50	Reported 18 gpm, drawdown 1 to 2 ft.
S	...do...	...	...	
S	...do...	...	...	
D	...do...	...	...	Reported 12 gpm, hardness 120 ppm.
D, S	...	...	...	

Table 13.—*Records of wells principally above the valley floor of*

No.	Well: Location no.	Well: Field name	Owner or name	Driller	Date completed
					Dona Ana County,
119	26.1.4.320	Afton well........	Mrs. Annie Braidfoot....	Shell Norwood.....	1943......
120	26.1.4.410	Afton............	Southern Pacific Co......	RR. employees...	August 1918.
121	26.1.16.330	Malpais Norwood	Mrs. Annie Braidfoot.....	Shell Norwood.....	....
122	26.1.25.410	Headquarters New	..........do..........	..........do..........	1946......
123	26.1.25.410a	Headquarters Old	..........do..........	..........do..........	....
124	27.1E.11.330	Lanark No. 1......	Southern Pacific Co......	....	1899......
125	27.1E.11.330a	Lanark No. 2......	..........do..........	....	1900......
126	27.1E.11.330b	Lanark No. 3......	..........do..........	....	1900......
127	27.1E.17.210	Lanark............	Mrs. Annie Braidfoot.....	Bob Payne..........	1944......
128	27.1E.33.130	Payne.............	..........do..........	..........do..........	1941......
129	27.1.8.340	Kilbourne Hole...	..........do..........	....	....
130	27.1.26.430	....	..........do..........	....	....
131	27.1.32.120	Little Hole well..	..........do..........	Shell Norwood....	1910 (?)..
132	27.2.2.320	North wells........	..........do..........	Bob Payne..........	1946......
133	28.2E.24.110	Strauss, well 1......	Southern Pacific Co......	....	1917......
134	28.2E.24.110a	Strauss, well 2......	..........do..........	....	1918......
135	28.2E.24.110b	Strauss, well 3......	..........do..........	....	1945......
136	28.2E.31.340	....	R. A. Gardner..........	....	1910 (?)..
137	28.3E.3.121	....	Ramon Morales..........	Ramon Morales...	1936......
138	28.3E.5.140	....	R. A. Gardner..........	....	....

No.	Location no.	Depth to which well is cased (ft)	Water level: Below land surface (ft)	Water level: Date of measurement	Type of pump	Kind of power
						Dona Ana County,
119	26.1.4.320	445	445	....	Pl	G
120	26.1.4.410	702	385	August 1918........	AL	S
121	26.1.16.330	445	406	1947..............	Pl	G
122	26.1.25.410	450	450	..........do........	Pl	G
123	26.1.25.410a	450	430	..........do........	Pl	G
124	27.1E.11.330	950	365	1899..............	None	....
125	27.1E.11.330a	615	365	1900..............	None	....
126	27.1E.11.330b	646	365	..........do........	None	....
127	27.1E.17.210	396 (?)	390	1944..............	Pl	W, G
128	27.1E.33.130	453 (?)	450	1941..............	Pl	W
129	27.1.8.340	....	....	....	....	....
130	27.1.26.430	314 (?)	310 286.39	.... Mar. 7, 1947......	Pl	W, G ....
131	27.1.32.120	280	280	....	Pl	W
132	27.2.2.320	406	400 (?)	....	Pl	G
133	28.2E.24.110	975	342 340	1917.............. 1941..............	AL	Steam
134	28.2E.24.110a	705	342 330	1918.............. 1941..............	AL	Steam
135	28.2E.24.110b	507	328	1945..............	T	E
136	28.2E.31.340	335	325 298.5	.... May 6, 1947......	Pl	W, G
137	28.3E.3.121	140	15	1947..............	C	E
138	28.3E.5.140	110	80-85 52.36	.... Aug. 28, 1947	Pl	W

the Rio Grande in Sierra and Dona Ana Counties, N. Mex.— Continued

Topographic situation	Altitude above sea level (ft)	Type of well	Depth of well (ft)	Diameter of well (in.)	Principal water-bearing bed: Depth to top of bed (ft)	Principal water-bearing bed: Thickness (ft)	Principal water-bearing bed: Character of material
N. Mex.—Continued							
...	4,210 T	Dr	445	6	...	...	...
...	4,210 T	Dr	702	14	385	130	Fine sand.
Depression in malpais.	4,210 T	Dr	445	6	...	...	Sand.
...	4,190 T	Dr	460	5	...	...	Do.
...	4,190 T	Dr	450	6	...	...	Do.
...	4,170 T	Dr	950	10	754	31	Do.
...	4,170 T	Dr	615	12	415	185	Do.
...	4,170 T	Dr	646	10	425	...	Do.
On mesa...	4,170 T	Dr	396	6	...	...	...
...do...	4,150 T	Dr	453	6	...	...	...
...	3,945 T	Dr	...	...	...	...	...
...	4,090 T	Dr	314	6	...	...	...
Depression in malpais.	4,030 T	Dr	280	6	...	...	...
On mesa...	4,200 T	Dr	406	6	...	...	...
...	4,110 T	Dr	975	14	360	52	Sand.
...	4,110 T	Dr	705	15	382	101	Do.
...	4,110 T	Dr	550	8 (?)	...	...	Do.
...	4,110 T	Dr	400	7	325	75	Do.
...	3,765 T	Dr	140	2½	140	...	Do.
...	3,820 T	Dr	110	6	100	10	Gravel.

Use of water	Quality	Measuring point: Description	Measuring point: Height above (+) or below (-) land-surface datum (ft)	Remarks
N. Mex.—Continued				
S	Good	...	...	Reported 10 gpm.
RR	Poor	...	...	Water did not rise. Reported 100 gpm, drawdown 15 ft.
S	Good	...	...	Reported 7 gpm.
D,S	...do...	...	...	Reported 7 gpm. See analysis.
D,S	...do...	...	...	Reported 8 gpm.
A	...	...	...	Well abandoned and covered.
A	Fair	...	...	Reported 33 gpm. Water struck at 415 ft. Well abandoned and covered.
A	...do...	...	...	Reported 33 gpm. Water struck at 425 ft. Well abandoned and covered.
S	Good	...	...	Reported 15 gpm.
S	...do...	...	...	See analysis.
A	Bad	...	...	Abandoned, not fit for use.
S	Good	Top of casing...	+0.50	Reported 15 gpm.
...	...	...	...	
S	...do...	...	...	
S	...do...	...	...	Reported 12 gpm.
RR	Fair	...	...	Water struck at 360 ft. Original depth 1,330 ft in 1907. Reported 30 gpm, drawdown 110 ft.
RR	...do...	...	...	Water struck at 382 ft. Reported 40 gpm, drawdown 120 ft. See analysis.
RR	...	...	...	Reported 250 gpm, drawdown 16 ft.
S	...	Top of casing...	+.30	
D,S	Good	...	...	El Paso County, Tex.
D,S	...	Top of casing...	.00	

Table 13.—*Records of wells principally above the valley floor of*

No.	Well: Location no.	Well: Field name	Owner or name	Driller	Date completed
					Dona Ana County
139	29.1E.6.110	....	R. A. Gardner............	....	....
140	29.1E.8.210a	Noria, well 2.....	Southern Pacific Co......	Layne & Bowler, Inc.	April...... 1914.
141	29.1E.8.210b	Noria, well 3.....	..............do.............	..........do..........	December 1916.
142	29.3E.12.300	....	J. A. Wilson..............	J. A. Wilson.......	1926.......
143	29.4E.7.440	....	Archie Bond...............	Archie Bond........	1925 (?)..
144	29.2.6.230	Mt. Riley, well 2	Southern Pacific Co......	....	December 1914.
145	29.2.12.240	Potrillo............	..............do.............	....	....
146	29.4.9.100	Malpais, well 1...	..............do.............	W. McLees.........	1903.......
147	29.4.9.100a	Malpais, well 2...	..............do.............	RR. employees..	1909.......

No.	Location no.	Depth to which well is cased (ft)	Well level: Below land surface (ft)	Well level: Date of measurement	Type of pump	Kind of power
						Dona Ana County,
139	29.1E.6.110	....	265	....	Pl	W
140	29.1E.8.210a	565	321	1914................	AL	Steam
141	29.1E.8.210b	560	320 (?)	1916................	AL	Steam
142	29.3E.12.300	....	147.80	Aug. 28, 1947.....	Pl	W
143	29.4E.7.440	60	44.26	..........do..........	Pl	W
144	29.2.6.230	518	278 278	1914................ 1941	Pl	Diesel
145	29.2.12.240	....	220	....	....	....
146	29.4.9.100	370	267	1903................	None	....
147	29.4.9.100a	479	255	1909................	None	....

the Rio Grande in Sierra and Dona Counties, N. Mex.—Continued

Topographic situation	Altitude above sea level (ft)	Type of well	Depth of well (ft)	Diameter of well (in.)	Principal water-bearing bed: Depth to top of bed (ft)	Principal water-bearing bed: Thickness (ft)	Principal water-bearing bed: Character of material
N. Mex.—Continued							
....	4,130 T	Dr	400	7	....	....	....
....	4,120 T	Dr	565	13	....	....	....
....	4,120 T	Dr	560	18	418	42	Sand.
....	3,895 T	Dr	190	4	....	....	....
....	3,790 T	Dr	60	6	....	....	....
....	4,110 T	Dr	528	13	280	20	Sand.
....	4,247 T	Dr	240	....	....	....	....
....	4,125 T	Dr	445	6	....	....	....
....	4,125 T	Dr	514	10	387	39	Sand.

Use of water	Quality	Measuring point: Description	Measuring point: Height above (+) or below (-) land-surface datum (ft)	Remarks
N. Mex.—Continued				
S	Good	....	....	
RR	Poor	....	....	Water struck at 425 ft. Reported 20 gpm, drawdown 100 ft.
A	....	....	....	Water struck at 418 ft. Reported 23 gpm.
D, S	....	Top of casing........	+1.50	
D	Good	........do........	+2.00	
RR	....do....	....	....	Temperature 65 F. 574 ppm total dissolved solids. Reported 22 gpm, drawdown 100 ft. Original depth 715 ft.
A	....	....	....	See Water-Supply Paper 188, p. 40.
A	....	....	....	770 ppm total dissolved solids. Reported 18 gpm.
A	....	....	....	Water struck at 387 ft. Reported 5 gpm.

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